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BASIC FIELD MANUAL

Volume III
BASIC WEAPONS

PART FOUR
HOWITZER COMPANY

Prepared under the direction of the
Chief of Infantry

for change no. 1, 1938 see bound vol.

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Part Four, Howitzer Company, Basic Field Manual, Volume III, Basic Weapons, is published for the information and guidance of all concerned.

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BY ORDER OF THE SECRETARY OF WAR:

DOUGLAS MACARTHUR,
General,
Chief of Staff.

OFFICIAL:

C. H. BRIDGES,
Major General,
The Adjutant General.

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III. *Basic Weapons.* (B. W.)—Marksmanship and mechanical training of the rifle, automatic rifle, pistol, machine gun, 37-mm gun, 3-inch trench mortar, bayonet and grenade instruction, technique of fire (37-mm gun, 3-inch trench mortar, and machine gun); musketry and combat practice of small units; instruments.

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Signal Corps Field Manual. (S. C. F. M.)

Vol. I. *Signal Corps Troops.*
II. *Signal Corps Operations.*

FOREWORD

Basic Field Manual, Volume III, Basic Weapons, will be published in six parts as follows:

PART ONE. Rifle company. (Each chapter of Part One will be published as a separate pamphlet.)

CHAPTER 1. Rifle marksmanship.
2. Automatic rifle marksmanship.
3. Automatic pistol marksmanship.
4. Instruction with the bayonet.
5. Instruction with hand and rifle grenades.
6. Musketry.

PART TWO. Fire-control instruments.

CHAPTER 1. Machine-gun instruments.
2. 37-mm gun and 3-inch trench mortar instruments.
3. Care, repair and adjustment of instruments.

PART THREE. Machine-gun company.

CHAPTER 1. Mechanical training with the machine gun.
2. Machine-gun marksmanship.
3. Technique of machine-gun fire.
4. Barrages and concentrations.

PART FOUR. Howitzer company.

CHAPTER 1. Mechanical training with the 37-mm gun and the 3-inch trench mortar.
2. 37-mm gun and the 3-inch trench mortar marksmanship.
3. Technique of the 37-mm gun and the 3-inch trench mortar fire.

PART FIVE. Combat practice firing.

CHAPTER 1. General.
2. Rifle company.
3. Machine-gun company.
4. Howitzer company.

PART SIX. Antiaircraft marksmanship—Infantry weapons. (Each chapter of Part Six will be published as a separate pamphlet.)

CHAPTER 1. General.
2. Rifle and automatic rifle.
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BASIC FIELD MANUAL

VOLUME III, BASIC WEAPONS
PART FOUR

HOWITZER COMPANY

(The matter contained herein supersedes TR 150–40, April 8, 1930, 420–30, May 17, 1924 (including C1, January 2, 1929), and 420–35, April 11, 1924.)

CHAPTER 1

MECHANICAL TRAINING WITH THE 37-MM GUN AND THE 3-INCH TRENCH MORTAR

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SECTION I

INTRODUCTION

1. General principles.—Instruction in mechanical training must be sufficiently thorough and progressive to insure that each member of the unit will be familiar with the weapon, its operation, care and cleaning, stoppages, and the common-sense remedies therefor. Nomenclature should be learned by a continual association of the name with the part, and by mentioning the name of any part each time it is touched rather than by learning an abstract list of names. Those undergoing instruction should be divided into small groups, and each group so arranged around the weapon that it may be seen by all. Each phase of instruction should first be carefully explained and demonstrated, and then followed immediately by a period in which each individual receiving instruction is required to repeat

the explanation and demonstration. The individual undergoing instruction is assisted by the group leader when necessary, and is criticized and checked by the other members of the group.

SECTION II

37-MM GUN AND CARRIAGE, M1916

2. Characteristics.—The 37-mm gun, M1916, is a flat trajectory weapon of the field-gun type which fires high-explosive or low-explosive shells, or solid projectiles that weigh slightly more than a pound. It is essentially an infantry weapon and is of such weight and construction as to accompany the infantry battalion on the march or in the attack. Three general methods of transportation of the weapon under these conditions are used: Limber and gun attached and drawn by a mule or horse; the gun on wheels, unlimbered, drawn by the gun squad; and the gun dismounted, separated into three loads consisting of barrel and cradle, tripod, and wheels and axle, the first two loads being carried, the wheels and axle being pushed.

General data

Weight of barrel and cradle group	pounds	88
Weight of trails (complete tripod mount), about	do	86
Weight of wheels and axle	do	166
Weight of gun and carriage, complete	do	340
Length of barrel	inches	29.133
Length of recoil	do	7 to 10
Maximum angle of elevation	degrees	21
Amount of traverse to right	do	22
Amount of traverse to left	do	16
Diameter of wheels	inches	37.5
Over-all length of vehicle	do	75
Over-all width of vehicle, trails spread	do	57
Over-all width of vehicle, trails closed	do	39.25
Oil capacity of cradle	pints	2.75
Weight of ammunition chest, capacity 16 rounds (empty), approximately	pounds	8
Weight of 1 round, HE shell	do	1.572
Weight of 1 round, LE shell	do	1.435
Weight of chest containing 16 rounds HE shell	do	33.15
Weight of chest containing 16 rounds LE shell	do	30.96
Muzzle velocity HE shell	feet per second	1,276
Muzzle velocity LE shell	do	1,312
Rate of fire, maximum (aimed fire)	rounds per minute	25

3. Description.—For a detailed description of the gun and carriage, see TR 1300–37A.

a. Barrel assembly.—The barrel assembly consists of the following principal parts: Barrel; breech ring, which is screwed on the rear end of the barrel, forming a recess for the breechblock; breechblock, which closes the chamber for firing, and carries the extractor mechanism and some of the firing mechanism; jacket and jacket shoe which form the rear support for the barrel, the shoe forming also a guide for the barrel during recoil; clip, which forms the front support and guide for the barrel.

b. Cradle.—The cradle is located below and supports the barrel. It is provided with trunnions and a bracket for attachment to the carriage, and carries a bracket, on the left side, for the attachment of the sight. The recoil cylinder of the cradle contains the recoil mechanism. A hole is provided through the front cap for filling the recoil cylinder with oil. On the right rear upper surface of the cradle is the drain plug which closes the overflow hole.

c. Tripod.—The tripod comprises the following principal parts: Two trails, front leg, pintle, pintle socket, elevating mechanism, and traversing mechanism.

(1) The trails, right and left, are made of steel of channel-iron sections. Riveted to the front of each trail is a trail head, and to the rear end a trail spade. Axle stay-clamp blocks, movable in the mortises formed by the trail reenforcement plates, are provided, to which the axle stays are hooked when the gun is on wheels. A traversing-screw bushing for the attachment of the traversing screw, through which this screw passes when the trails are closed, is on each trail. There is also on each trail a lunette swivel through which the cleaning brush staff is placed when the gun is drawn by hand, and a single-tree eye which is used for joining the gun to the limber.

(2) In addition to the description given in (1) above, which is common to both trails, there are on the left trail two trail-brace-chain eyebolts for securing the trail brace to the trail. On the right trail are the front and rear shoulder-guard brackets which carry the shoulder guard when not in position for firing, the cleaning brush-staff fastening (front), and the cleaning brush-staff fastening (rear) with cleaning brush-staff plunger and spring for carrying the cleaning-brush staff, and the trail-

brace locking-plate with which the trail brace is hooked when the trails are spread, thus holding the trails apart.

(3) The front leg is attached to the pintle socket by two front-leg pins. Two elevations in mounting are possible through the provision of two different holes for the lower pin. Attached to the lower end of the leg is the front-leg float, an enlarged bearing surface to minimize sinking in wet or loose soil when firing from the tripod mount.

(4) The pintle socket affords the central connection between the tripod and the wheels by engaging the pintle socket bearing (by means of the stud formed on the pintle socket). To it, also, is attached the front leg. The pintle socket and trails form a joint, the three parts being joined together by the pintle bushing, which passes through them, forming a common axis pin.

(5) The pintle, or gun mount, is in the form of a yoke, the upper ends being fitted to receive the cradle trunnions. The pintle is projected downward from the yoke, forming a pivot which fits into the pintle bushing. Projecting through the pintle bushing, the lower end is tapped to receive the pintle-retaining plug, which holds it in place. The front-leg shackle is suspended from the pintle-retaining plug, to which it is fastened by the front-leg shackle screw.

(6) The elevating mechanism is supported on the rear end of a Y-shaped frame, which is secured to the pintle at its upper and lower ends. The elevating screw passes through the elevating-screw nut, which is threaded to receive it, and it in turn is pivoted in the elevating-screw-nut bracket. Elevation is secured by turning the elevating-screw handwheel attached to the upper end of the elevating screw.

(7) A mechanism is provided below the elevating-screw nut to lock the elevating gear in position. Above the handwheel is the elevating-screw latch housing, which engages the elevating-screw-latch-catch bracket on the under side of the cradle.

(8) Traversing is accomplished by lateral movements of the elevating screw and nut bracket and the Y-shaped frame, the front ends of the latter being securely attached to the pintle carrying the cradle and barrel. In rear of the point where the elevating-screw nut pivots, the elevating-screw-nut bracket forms a fork and engages the traversing screw-nut housing. A traversing-screw nut, threaded to engage the traversing screw, is placed in the traversing-screw-nut housing, and may be re-

volved by a traversing handwheel attached to the nut. This turning causes the lateral movement or traverse, as the traversing screw is prevented from rotating by the traversing-screw lock located in the right traversing-screw bearing.

d. Axle and wheels.—The axle is provided with a spindle at each end, to which are fitted the wheels. At its center, on the lower side, is the pintle socket bearing, into which the socket stud is placed when the tripod is attached to the axle. An axle-coupling pin, attached to the axle by a chain to prevent loss, passes through a hole in the socket stud, securing the tripod to the axle. On either side of the pintle socket bearing, an axle stay is attached. These are hooked into the axle-stay-clamp blocks on the trails, and assist in securing the axle to the tripod. The axle lock, which is assembled underneath the pintle socket bearing, fits between the flanges of the pintle socket or may be swung out of engagement with it, and is held in the desired position by inserting the axle-coupling pin on the proper side of the axle-lock stop. When the gun is supported on the wheels in firing, the axle lock must be swung out of engagement with the pintle socket (unlocked). At all other times, and especially during transportation of the gun on wheels, the axle lock should be engaged with the pintle socket (locked).

4. Dismounting and mounting—*a. Dismounting.*—(1) *To remove the barrel and cradle from the mount.*—Cock the gun. Open the breech. Insert the cleaning brush staff through the bore from the breech. Press down on the trunnion-cap latches and turn the trunnion-cap wing nuts to the front. Grasp the cleaning-brush staff with the left hand and the elevating handwheel with the right. Press in on the elevating-screw latch with the forefinger of the right hand and separate the elevating screw from the elevating-screw latch-catch bracket by pushing forward on the elevating handwheel. By means of the cleaning-brush staff, lift the barrel and cradle from the mount.

(2) *To unlock the axle lock.*—Draw the axle-coupling pin upward about 1 inch, pull the axle lock forward, and replace the axle-coupling pin behind the axle-lock stop.

(3) *To remove the axle and wheels from the tripod.*—Remove the barrel and cradle from the mount. Pull out the axle-coupling pin. Straddle the trails. Unhook the axle stays and raise the front of the trails slightly. Remove the axle and wheels to the front, separating the pintle socket bearing from

the socket stud. Lower the trails to the ground gently, as dropping them may injure the front-leg shackle.

(4) *To mount the gun on the tripod the gun and tripod being removed from the axle.*—Straddle and raise the front of the trails. Hold them between the knees. With the right hand remove the front-leg pin from the front-leg shackle, allowing the front leg to fall. Lock the front leg in position by inserting the front-leg pin in the upper opening in the bronze housing and through the front leg. Lower the front leg to the ground. Unstrap the trail straps. Spread the trails and adjust the trail brace by inserting the trail-brace tongue in the right trail. Place the barrel and cradle on the trunnion bearings. Adjust the latch housing on the elevating screw to the elevating-screw-latch-catch bracket, and lock the trunnions. Remove the cleaning-brush staff. Close the breech. Uncock the gun.

(5) *To remove the wheels from the axle.*—Pull down the linch pin ring and turn the wheel until the recess in the hub is in line with the head of the linch pin. Remove the linch pin and washer. Lift off the wheel. Replace the washer and linch pin.

(6) *To assemble the gun and tripod on the wheels, the gun being mounted on the tripod.*—Remove the barrel and cradle from the tripod. Disengage the trail brace from the right trail and place it on the left. Pull down on the traversing-screw-lock ring and close the trails. Strap the trails together by means of the trail strap. Straddle and raise the front of the trails. Grasp the trails between the knees, withdraw the front leg pin from the bronze housing, and fold back the front leg. Secure the front leg in the front leg shackle by means of the front leg pin. Insert the socket stud into the pintle socket bearing, hook the axle stays, lock the axle lock, and insert the axle-coupling pin into the socket stud. Replace the barrel and cradle on the mount.

b. Mounting.—The operation of remounting may be accomplished by reversing the order of dismounting.

5. Disassembling and assembling—*a. To remove the breechblock and extractor from the breech ring.*—Cock the gun. Push the extractor pin to the right with a finger of the left hand. Remove the extractor pin to the right. Press in on the breechblock-lever-release-pin cap and remove the breechblock lever. Place the thumb of the right hand in the port of the breechblock, and the left hand, palm up, under the breechblock,

Unscrew the breechblock by turning it to the left. Lift the extractor from its seat.

b. To replace the extractor and breechblock in the breech ring.—Replace the extractor in its seat in the breech ring. Cock the gun if it is not already cocked. Screw the breechblock into the breech ring. Replace the breechblock lever. With the left hand below the breech ring, raise the extractor and, with the right hand, return the extractor pin from right to left. Uncock the gun.

c. To remove the barrel from the cradle.—(1) Level the barrel by means of the elevating screw. Open the breech. Uncock the gun. Press up on the piston crosshead key latch with the thumb and index finger of the right hand, and remove the piston crosshead key to the left. Insert the cleaning-brush staff through the bore from the breech and remove the barrel to the rear, being careful that the bronze shoes do not become damaged by allowing the rear end of the barrel to bear down. To overcome any possibility of damage to the shoes, it is advisable that two men remove the barrel.

(2) To replace the barrel, reverse the order of dismounting, exercising necessary care to insure the sear being returned in the proper relative position with the trigger crank and safety bolt.

d. To remove the striker and striker spring from the striker housing.—(1) Depress the muzzle of the barrel slightly. Remove the piston crosshead key. Slide the barrel to the rear about 7 inches. Push the striker to its complete forward position and unscrew the nut from the striker rod. Release the pressure on the cocking handle and pull out the striker and striker spring.

(2) To replace the striker and striker spring, reverse the order of dismounting.

e. To disassemble the breechblock.—(1) Remove the breechblock from the breech ring. Remove the rocker pin by drawing it toward the center of the port. Lift out the rocker. Place the hand over the rocker seat and turn the breechblock over, allowing the rocker plunger, firing pin, and firing-pin spring to drop out.

(2) To assemble the breechblock, reverse the order of disassembling.

6. Operation—*a. To cock the gun.*—Place the palm of the hand against the cocking handle and push the striker forward

quickly until the head of the sear engages in the cocking notch of the striker. Cocking by hand is necessary only for the first round.

b. To uncock the gun.—Close the breech, if not already closed. Place the palm of the left hand against the cocking handle, press on the trigger-crank lever with the thumb of the right hand, and allow the striker to come back gently.

c. To open the breech.—Cock the gun. Rotate the breechblock by moving the breechblock lever to the left until it meets the shoulder which limits the movement of opening.

d. To close the breech.—Rotate the breechblock by moving the breechblock lever to the right until it meets the shoulder which limits the movement of closings. The hand must be kept on the breechblock lever until the lever comes in close contact with the shoulder which limits the movement of closing in order to avoid any return movement of the breechblock.

e. To load.—Open the breech. Insert a round into the chamber by grasping it by the base, placing it in the port in the breechblock and pushing it into the chamber with the fingers. Close the breech.

f. To unload.—Open the breech smartly. The opening of the breech causes the extraction and ejection of the cartridge case.

7. Cleaning—*a. Bore, chamber, and breech ring.*—Ordinary cleaning after firing, by means of waste or rags, includes the following: Remove the breechblock. Thoroughly sluice and sponge the bore and chamber with either hot water and issue soap, salsoda solution, hot water alone, or, in the absence of these, with cold water. Then, with dry waste or rags, swab the bore and chamber until they are perfectly dry and clean. Finally, oil the parts lightly, making certain that the oil covers all the surface of the bore. This cleaning should be done as soon as practicable after firing. If the gun is not to be fired for several days, a daily inspection should be made to determine whether further cleaning is necessary. If the gun is to be stored for an appreciable period, a heavy grease, such as rust-preventive compound (U. S. Army Spec. No. 2–82), should be applied as a preservative. The interior of the breech ring should be cleaned and then wiped with an oily rag.

b. Breechblock.—Remove the breechblock from the breech ring and disassemble it. With a dry rag clean the dirt and oil from the block and all parts contained therein. Using light oil, lubricate the recesses for the firing pin, rocker, and rocker

plunger. With an oily rag wipe the breechblock leaving a thin coating of oil especially on the threads and on the face of the block.

c. Extractor and sear.—Remove the extractor and sear from the gun, and clean and oil by wiping thoroughly, first with a dry rag and then with an oily rag. Oil the recesses for the extractor pin and sear plunger before replacing these parts.

d. Outer surfaces of gun.—Clean the outer surfaces, using gasoline if necessary, then dry and wipe all exposed metal parts with a lightly-oiled rag. Oil the interior of the striker housing. Place a drop of oil in the recesses for the striker and the safety bolt.

e. Tripod.—Clean the outer surfaces, including the mortises of the axle-stay clamps and the holes through which the traversing screw passes. Oil lightly the trunnion bearings, pintle bushing, socket stud, bearings of the traversing screw, the traversing screw, traversing-screw plunger, elevating-screw latch housing, elevating-screw nut, and elevating screw.

f. Axle and wheels.—Wash with water, using a sponge, to remove dirt and other fouling that gathers during transportation. Oil the pintle socket bearing lightly. Grease the axle spindles at intervals to suit circumstances, insuring that they are properly lubricated at all times.

g. Guides, jacket shoe, and clip shoe.—Remove the barrel from the cradle. With a cloth wet with gasoline, clean the inner surfaces of the guides and the outer surfaces of the shoes, then dry the parts. Grease liberally with a heavy oil and reassemble. This will be necessary only in sandy country or under other unusual circumstances.

8. Special precautions during unusual conditions—*a. Cold weather.*—The gun should be tested frequently by hand manipulation to insure that it is functioning properly.

b. Gas attack.—Lids on ammunition chests should be closed and, if practicable, a heavy coating of thick oil applied to the bore and working parts of the gun. Directly after the gas attack, the gun should be thoroughly cleaned, using hot water containing a little soda if obtainable. The ammunition should be wiped with an oily rag and fired as soon as tactical conditions permit. Ammunition that has been subjected to the action of gas should be very carefully and thoroughly inspected before firing.

9. Filling the recoil cylinder of the cradle.—*a.* The recoil cylinder has a capacity of about 2.75 pints of oil. It must be kept properly filled in accordance with the following instructions, or damage to the gun will probably result. The Ordnance Department will furnish the proper grade of oil for recoil cylinders when the following specification is used: "Oil, recoil, heavy, U. S. Army Spec. No. 2–36." The substitution of any filler other than that issued by the Ordnance Department is prohibited.

b. To fill the recoil cylinder, proceed as follows:

(1) By means of the elevating screw depress the muzzle as far as possible.

(2) Fill the oil gun with oil. (Unscrew the cap with muzzle attached, draw the piston back to its full extent, fill the cylinder, screw on the cap with nozzle attached, and, with the nozzle pointing upward, push in the piston until oil starts to flow, in order to force the air out of the oil gun.)

(3) Unscrew the filling plug in the front-end cap of the recoil cylinder and screw the nozzle end of the oil gun into position in its stead.

(4) Unscrew the drain plug.

(5) Introduce the oil into the recoil cylinder by slowly pushing in the piston of the oil gun, and continue until the oil escaping through the overflow hole (from which the drain plug was removed) no longer carries air bubbles.

(6) Holding a finger over the overflow hole to prevent rapid escape of oil, unscrew the oil gun, and allow about 1 spoonful (spoon issued with mess equipment) of oil to escape.

(7) Screw both plugs tightly in place.

10. Practices to be avoided in the use and operation of the gun.—*a.* Snapping the percussion mechanism when the chamber is empty.

b. Pressing the trigger crank lever, the breech not being completely closed.

c. Rotating or attempting to rotate the breechblock, the gun being uncocked.

d. Putting a strain on the shoulder guard, either in carrying the gun or by leaning on it while getting into or out of the gunner's position on the left trail.

e. Putting a strain on the elevating handwheel by allowing the rear end of the cradle to drop, or to rest on it when the elevating screw is unlatched from the elevating-screw-latch-

catch bracket in removing the gun from the mount. The material of which the handwheel is made is quite brittle and will not stand rough handling.

11. Defects and stoppages.—Defects and stoppages do not occur with sufficient frequency to warrant a special form of drill in remedying them. They are listed herein for information. Such instruction will be given the soldier in their nature and the action necessary to remedy them as will insure the most efficient operation of the gun.

a. When the breech can not be opened and inspection discloses that the gun is not cocked—(1) *Causes.*—(*a*) Failure to release pressure on the trigger crank lever when the gun fires.

(*b*) Worn or broken sear, or weak sear spring.

(2) *Action to remedy.*—Cock the gun. Caution the firer to release pressure on the trigger crank lever when the gun fires. If the gun will not cock, replace the defective part.

b. When the breech can not be opened and inspection discloses that the gun is cocked—(1) *Causes.*—(*a*) The firing pin is engaged in the primer because of a weak or broken firing-pin spring or burred or dirty rocker mechanism.

(*b*) The piston crosshead key has not been fully inserted with the result that the safety bolt is not withdrawn from the notch in the breechblock cap.

(2) *Action to remedy.*—(*a*) Withdraw the safety bolt from the notch in the breechblock cap and insert the piston crosshead key properly.

(*b*) Tap with some soft object on the protruding part of the rocker and work the breechblock lever until the firing pin comes loose. This failing, insert the cleaning-brush staff into bore from the muzzle and tap the empty cartridge case. If this is not effective, remove the rocker and attempt to withdraw the firing pin. As a last resort break off the firing pin by forcing the breech open, replace the defective parts, and clean and oil the rocker mechanism. If the rocker mechanism is burred, smooth carefully with a fine file or emery paper.

c. When the gun fails to eject the empty cartridge case—(1) *Causes.*—(*a*) Failure to open breech smartly.

(*b*) Defective ammunition.

(*c*) Broken or worn extractor.

(*d*) Dirty chamber.

(2) *Action to remedy.*—(*a*) Close the breech and open smartly.

(*b*) If this is not effective, remove the empty case with the cleaning-brush staff by inserting the cleaning-brush staff through the bore from the muzzle; the hand extractor may also be used to remove rounds or empty cartridge cases from the chamber.

(*c*) Replace the extractor if necessary.

(*d*) Clean the chamber thoroughly.

d. When the gun fails to return completely into battery—(1) *Causes.*—(*a*) Dirty or burred slides or shoes; lack of grease on slides for shoes.

(*b*) Expansion of oil in the recoil cylinder because of overheating.

(*c*) Weak counterrecoil springs.

(2) *Action to remedy.*—(*a*) If necessary to continue firing, push the gun forward into battery by hand. When necessity for fire ceases, clean and grease the shoes and slides. If burred, smooth them carefully with a fine file or emery paper.

(*b*) If shoes or slides are not dirty or burred, unscrew the filling plug and allow about a spoonful (spoon issued with mess equipment) of oil to escape.

(*c*) Should the above remedies be ineffective, the gun should be returned to the Ordnance Department for repair.

12. Misfires.—Care must be used in handling misfires to avoid accident. When a misfire occurs the gun should be cocked by hand and, without opening the breech, the trigger crank lever should again be pressed. At least three attempts to fire the primer will be made. If the round still fails to fire, wait 10 minutes for a possible "hangfire," then remove the round from the chamber and examine its primer. If the primer be properly dented, the round is defective and should be discarded. If the primer be not dented, the firing pin is probably broken. It should be examined and replaced if necessary. If the primer be but slightly dented, the striker is improperly adjusted or the striker spring is weak. To adjust the striker, push it to its complete forward position, examine it, and screw up or unscrew the nut on the striker rod a few turns, the direction of screwing dependent upon the position of the nut. The 37-mm gun usually operates properly when the striker-rod nut is screwed to a position where the end of the rod is flush with the nut. If this action does not remedy the condition, replace the striker spring.

13. Ammunition—*a. Types.*—Two general types of ammunition are provided for the 37-mm gun; high explosive (HE) and

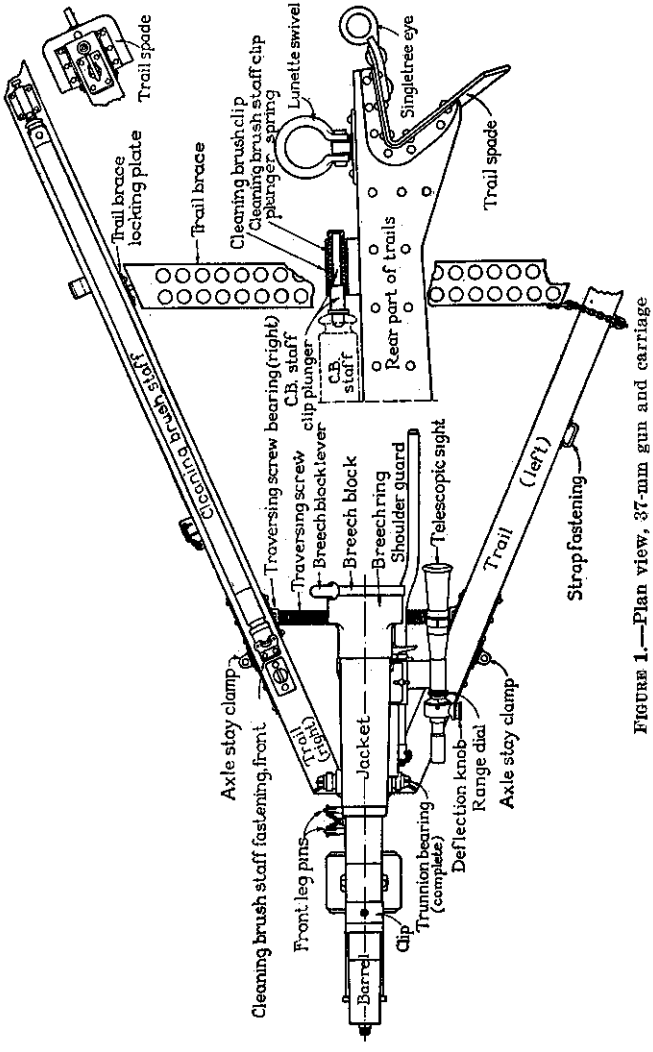


FIGURE 1.—Plan view, 37-mm gun and carriage

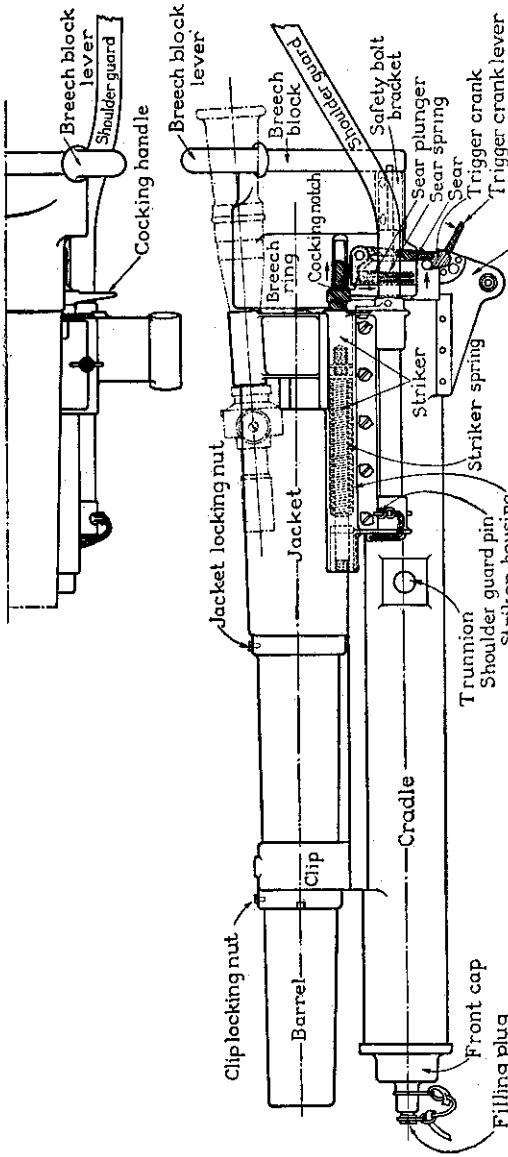


FIGURE 2.—Elevation, side view of gun and cradle, 37-mm gun

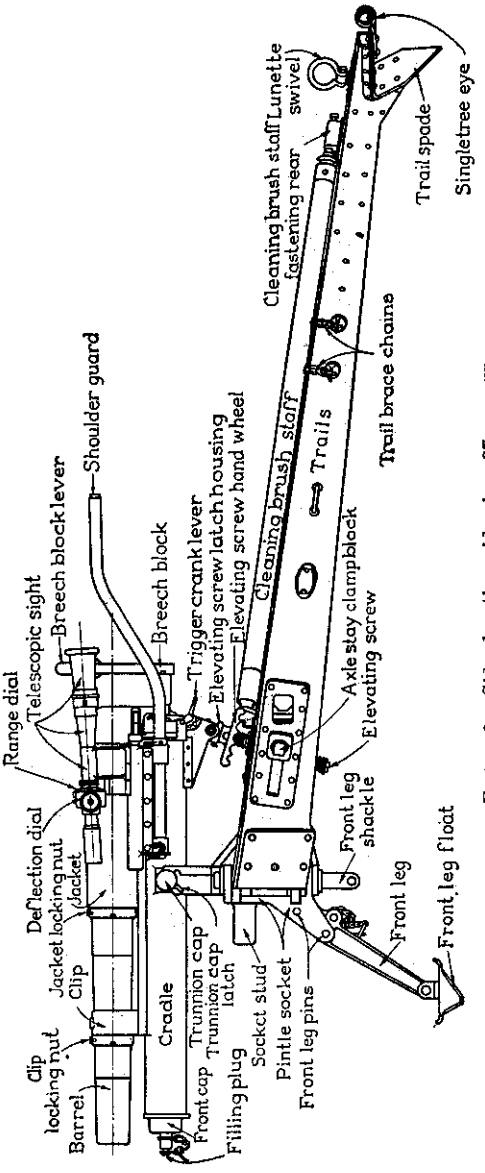


FIGURE 3.—Side elevation, side view, 37-mm gun

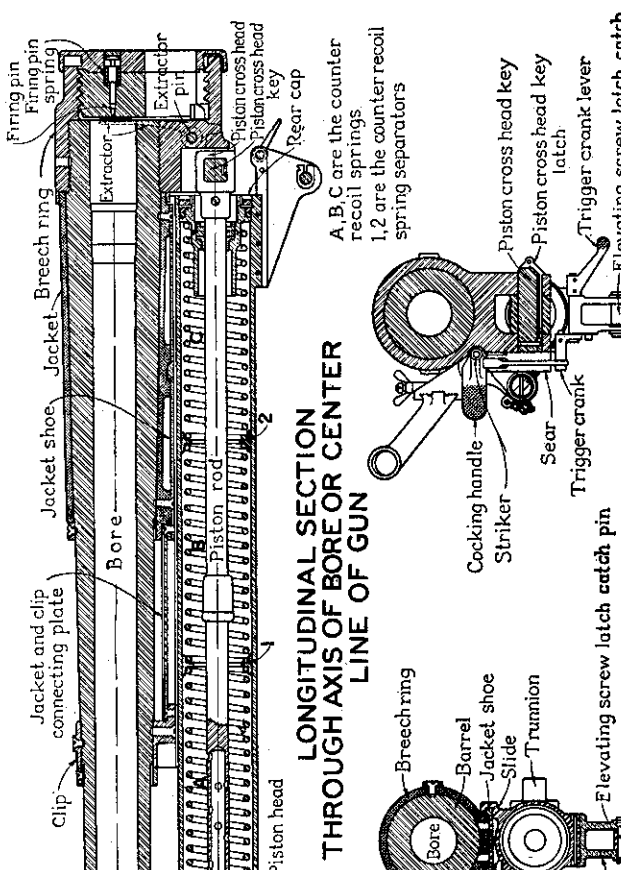


FIGURE 4.—Longitudinal section, 37-mm gun

low explosive (LE). The principal difference between these two types is in the projectile. In the high-explosive ammunition the shell, Mk. II, is loaded with TNT and fitted with a base detonating fuze. In the low-explosive ammunition the shell, Mk. I, is loaded with black powder and fitted with a base percussion fuze. The shell used in the high-explosive ammunition is slightly longer and heavier than that used in the low explosive; the exterior of the shell of the former is painted yellow, while the shell of the low explosive is painted red.

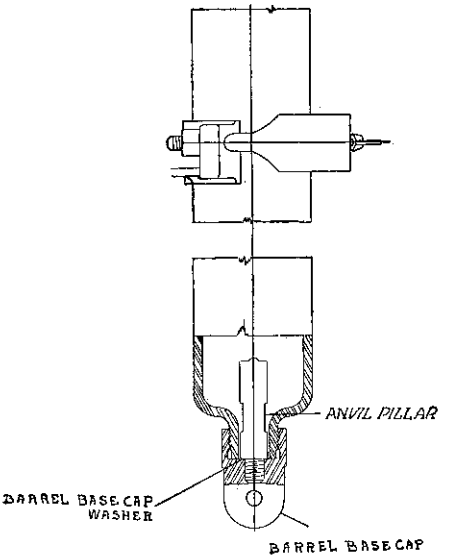


FIGURE 5.—3-inch trench mortar barrel and base cap

b. More detailed information pertaining to ammunition for the 37-mm gun is given in TR 1350–37A.

SECTION III

3-INCH TRENCH MORTAR, MK. I

14. Characteristics.—The 3-inch trench mortar is a smooth-bore, muzzle-loading, high-angle-fire weapon. The mortar consists essentially of a barrel, bipod, and a base plate. A list of

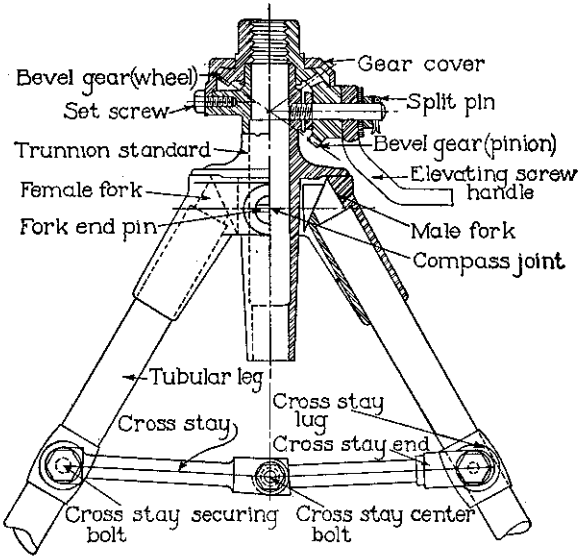


FIGURE 6.—Bipod

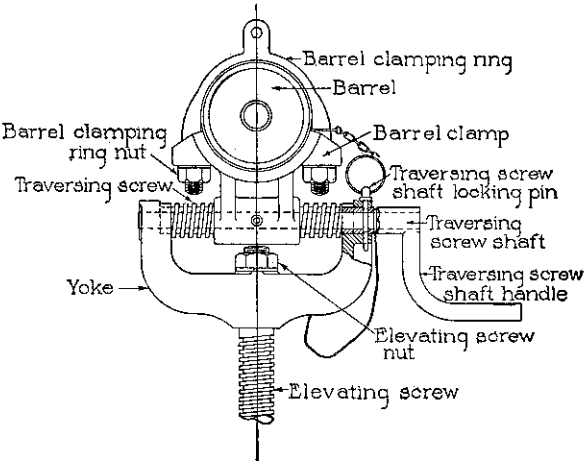


FIGURE 7.—Barrel and traversing mechanism

accessories, tools and spare parts accompanying the mortar may be found in Standard Nomenclature List No. D–5. A detailed description of the mortar and bipod may be found in TR 1300–3A.

Table of condensed data

Weight of barrel—pounds	43
Weight of bipod—do	37
Weight of base plate—do	33
Maximum traverse on base plate (right or left of normal)—degrees	6
Maximum traverse, traversing mechanism (right or left of center)—degrees	3
Maximum range—yards	750
Minimum range (normal emplacement)—do	150
Weight of 1 round, HE shell, ammunition—pounds	11.68
Weight of 1 round, practice shell, ammunition—do	11.68
Weight of 1 round, smoke-shell, ammunition—do	12.48
Rate of fire, maximum—rounds per minute	30
Rate of fire, sustained—do	6 to 10

15. **Dismounting and mounting**—*a. To dismount the mortar.*—Remove the traversing-screw-shaft locking pin and withdraw the traversing screw shaft. Lift the barrel, with the traversing screw attached, from the bearings in the yoke. Remove the barrel from the base plate. Replace the traversing-screw shaft and the traversing-screw-shaft locking pin. Raise the cross stays and close the legs of the mount.

b. To mount the mortar.—Place the base plate in position with indentations up and rope handle to the rear. Place the base cap of the barrel in the center indentation of the base plate. Open the legs of the mount and set the mount in position with cross stays to the front and the points of the yoke to the rear. Spring the cross stays past dead center. Remove the traversing-screw-shaft locking pin and withdraw the traversing-screw shaft. Place the ends of the traversing screw in the notches in the yoke which form the bearings. Insert the traversing-screw shaft, being certain that the lugs on the traversing-screw-shaft handle engage in the notches in the traversing screw. Fasten in position by inserting the traversing-screw-shaft locking pin.

16. **Disassembling and assembling**—*a. To disassemble the barrel.*—Unscrew the base cap from the barrel, using the tommy bar. Unscrew the anvil pillar from the base cap, using the combination wrench and tommy bar.

b. To assemble the barrel.—Screw the anvil pillar firmly into the base cap. Screw the base cap onto the lower end of the barrel and tighten it.

17. The base-plate pit—*a. General.*—Accuracy of fire with the 3-inch trench mortar is largely dependent upon good base-plate pit construction. The general area or emplacement for the mortar having been selected, the exact location for the pit is controlled by the following factors:

(1) *Field of fire.*—The pit must be so situated that when the mortar is properly aligned and mounted for firing the maximum traverse to the right and left and the maximum depression and elevation will be permitted. Objects such as trees, embankments, and houses must not be in the path of the projectile when the mortar is traversed, elevated, or depressed to its extreme limits.

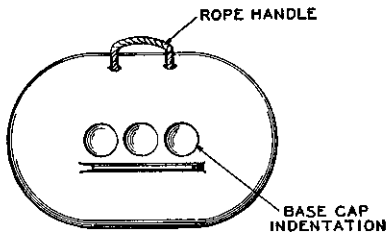


FIGURE 8.—Base plate, Mk. II (cast-steel type)

(2) *Character of soil.*—The pit should be prepared in the most favorable soil. A firm soil that will not crumble answers this requirement. When care is not used in selecting the ground in which to dig the pit, accuracy will not be obtained.

b. Characteristics.—The pit should be dug to such depth that when the base plate is placed therein, its top will be flush with the surface of the ground, and the rear wall facing the field of fire. The pit should be just the length of the base plate. The result desired is to insure that the shock or recoil is taken up by the base plate without changing the position of the barrel. This is accomplished by having the base plate snugly fitted in a well-prepared pit, and in a position approximately perpendicular to the barrel.

c. To prepare the pit.—Dig at the selected point a V-shaped hole, trimming the rear wall so that it inclines at an angle of

40° from the horizontal; with the oval-shaped base plate an angle of 36° will be found to be more efficient. The width and depth of the pit should be such as to secure the conditions set forth in *b* above. In wet or soft soil the pit should be reinforced. This may be done with bags partly filled with sand or earth, folded to the same length as the width of the pit and then *pounded with the back of a shovel until thoroughly packed.* If time permits, more efficient reinforcement can be secured by sinking short timbers, such as narrow-gauge railway ties, in the earth in such a position as to serve as the back wall of the pit. If this be done, several thicknesses of cloth, such as empty bags, should be placed between the base plate and timbers. If bags containing dirt be used, one should be placed on each inclined wall of the pit. The bag covering the front wall is placed first in order that the lower edge of the base plate will not be forced down between the bags when the mortar is fired. If this method of reinforcement be used, it will be necessary to dig the pit to a greater length than when no such reinforcement is utilized. The top of the bags should be even with the surface of the ground when placed in the pit.

18. **To fire the mortar.**—The ammunition having been properly prepared for firing and the mortar mounted and laid, the man who is to fire (No. 1 of the mortar squad) takes post on the right of the muzzle, facing it, his right foot near the lower part of the right leg of the mount. He takes the shell in his hands, right hand, palm up, around the fuze, safety fork in the palm of the hand; left hand, palm down, grasping the lower part of the casing near the base. The assistant (No. 2) pulls out the safety pin. The shell is started into the muzzle of the barrel, fuze end up, both hands retaining their grasp. At the signal to fire, the shell is released and slides to the bottom of the barrel, where the anvil pillar ignites the primer, which in turn ignites the propelling charge, and the shell is driven from the barrel. When the shell is released, the hands of the firer should instantly be withdrawn, the right hand moving under the muzzle, the left hand directly away from the muzzle. Neither hand should pass in front of the muzzle during the operation. The firer should also move his head away from the muzzle.

19. Care and cleaning—*a. Before firing.*—(1) All oil should be removed from the barrel; if the bore is oily, smoke will be given off and the position may be disclosed.

(2) The anvil pillar should be firmly screwed to the barrel base cap and the base cap firmly screwed to the barrel.

(3) The clinometer and mount should be inspected to insure serviceability.

(4) The muzzle cap should always be kept over the muzzle when the gun is not actually firing, as water seriously affects the range.

(5) The head, base, and cartridge container of the shell must be cleaned before firing.

b. During firing.—(1) The barrel should be swabbed out with a wad of cotton waste or rags after every five rounds.

(2) The barrel base cap and anvil pillar should be examined at every opportunity, cleaned, and tightened.

c. After firing.—(1) Unscrew the barrel-base cap and clean and sponge out the barrel, removing all residue. Lightly oil the bore.

(2) Clean the anvil pillar and then oil lightly.

(3) Clean the barrel-base cap and oil.

(4) Examine, clean, and oil all working parts of the bipod.

(5) Clean the base plate.

d. Precautions.—For safe and proper operation of the mortar the following precautions should be observed at all times:

(1) Remove the hands quickly from the muzzle of the mortar after releasing the shell.

(2) Always see that the upper and lower guides (head and base) of the shell are clean.

(3) Be sure that the cartridge end of the shell is pointed downward when firing and that the shell is dropped into the mortar, cartridge end first; otherwise a dangerous premature explosion may occur.

(4) Use green-colored cartridges only.

(5) See that the cartridge fits closely in the cartridge container.

(6) Never use more than three powder rings. If more than three are used, the pressure will be too great.

(7) The clinometer, when used, must be vertical.

(8) The clinometer must be removed before firing.

(9) The position of the mortar should invariably be checked after each of the first two rounds fired from any new position.

If the correction for the range required is only slight, firing may be continued, but as a rule the mortar should be checked after every five or six rounds. In dry weather when the ground is hard this precaution is not necessary as it may be easily observed whether the base plate has shifted and adjustments for range and deflection can be made.

20. Ammunition.—More detailed information pertaining to the 3-inch trench mortar ammunition is given in TR 1350–3A.

a. Types.—Three general types of ammunition are provided for the 3-inch trench mortar; high-explosive shell, smoke shell, and practice shell. The ammunition is not assembled for shipment and before firing it is necessary to assemble the booster, fuze, cartridge, and powder rings (if used) to the shell. These components should not be assembled until just prior to firing.

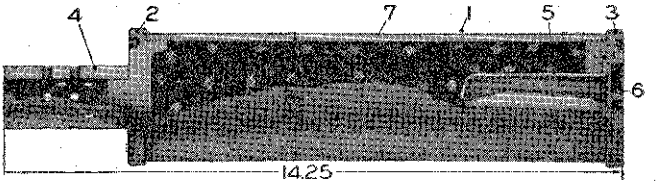


FIGURE 9.—3-inch trench mortar high-explosive shell, Mk. I

1. Casing.
2. Base.
3. Head.
4. Cartridge container.
5. Booster jacket.
6. Fuze hole plug.
7. Explosive charge.

All components of the round are packed in the same packing box but in different compartments.

(1) *High-explosive shell, Mk. I.*—The explosive charge of the high-explosive shell, Mk. I, consists of about 2.15 pounds of granular TNT. The shell, including the head, base, and cartridge container, is painted externally with yellow paint. It is stenciled in black, for identification, as follows: "3 T. M. Shell MK I, TNT." The booster used is the Mk. I booster. It is a paper cylinder, filled with two tetryl and one TNT pellet. In the top of the booster is a detonator similar to a No. 8 detonator or blasting cap. The detonator contains a mercury fulminate composition and is very sensitive.

(2) *Smoke shell, Mk. I.*—The smoke shell, Mk. I, contains 2.53 pounds of white phosphorus. The booster is the Mk. I, the same as used in the high-explosive shell. When the booster explodes it fragments the shell body and scatters the white phosphorus, which ignites spontaneously upon contact with the

air. The shell, including head, base, and cartridge container, is painted externally with a bluish-gray paint. It is stenciled in yellow, for identification, as follows: "3 T. M. Shell MK I, Smoke."

(3) *Practice shell, Mk. I.*—The practice shell, Mk. I, is filled with 2.15 pounds of sand to give it the same ballistic qualities as the high-explosive shell. A special black-powder booster is provided. On impact the booster blows the fuze out of the head of the shell and produces a puff of white smoke sufficient for observation of the strike. The shell, including the head, base, and cartridge container, is painted externally with dark-blue paint. It is stenciled in white as follows: "3 T. M. Shell MK I, Practice."

b. Principal parts of the shell.—There are three principal parts of the shell which are similar in all types of ammunition: The shell proper, the cartridge container, and the fuze. (Figs. 9 and 10.)

(1) The shell is a cylindrical steel casing into which a steel base and head are screwed.

(2) The cartridge container is a short steel tube which is screwed onto the base. It is pierced by 16 holes to permit escape of the gases generated by the explosion of the propellant cartridge.

(3) (*a*) The trench-mortar fuze, Mk. VI (fig. 10), used in all types of ammunition is known as the "Always" type of fuze, for the reason that it will function upon impact, regardless of the manner in which the shell strikes a resisting object. The safety pin is incorporated for safety in handling and shipment. It is a steel cotter pin and should be removed only just before loading the shell into the mortar. A ring is placed in the eye of the safety pin to facilitate its removal. The safety pin, when in position, passes through a hole in the set-back pellet (5), thus preventing any movement of the set-back pellet. The shank of the set-back pellet passes through a hole in the safety fork (8), thus locking it in position. The inner end of the safety fork is slotted, and this end passes through a hole in the sleeve (4), serving to hold the sleeve and the striker (2) apart. The safety fork forms a protective wall of metal between the striker (2) and the primer (9) in the sleeve (4).

(*b*) When the shell is dropped into the mortar, the combined forces of the shell striking the breech of the mortar and the

blow delivered to the shell by the propelling-charge gases cause the inertia or set-back of the set-back pellet (5) to overcome the resistance of the set-back pellet spring (12), and the set-back pellet moves toward the base of the fuze. This movement

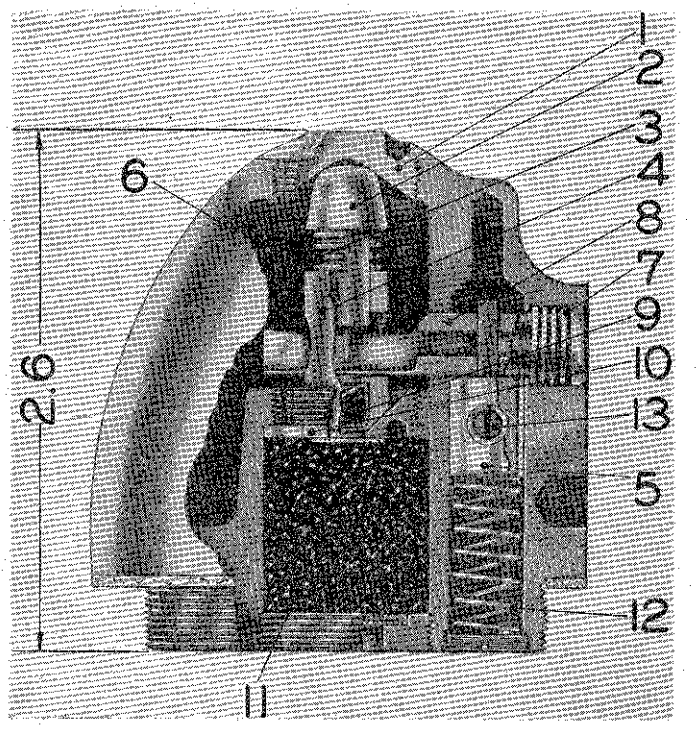


FIGURE 10.—3-inch trench-mortar fuze, Mk. VI

1. Upper cone cap.
2. Striker.
3. Striker spring.
4. Sleeve.
5. Set-back pellet.
6. Body.
7. Safety fork spring.
8. Safety fork.
9. Primer.
10. Lower cone seat.
11. Black powder.
12. Set-back pellet spring.
13. Safety pin.

withdraws the shank of the set-back pellet from the safety fork (8).

(*c*) The safety fork, now being released by the set-back pellet, is thrown outward by the action of the safety-fork

spring (7), but is prevented from leaving the fuze by striking and bearing against the bore of the mortar. Thus, the safety fork remains in position between the striker and the primer, preventing any possibility of the striker functioning the primer while the shell is in the mortar.

(*d*) When the shell passes out of the muzzle of the mortar, the safety fork (8) is ejected completely from the fuze, under the action of the safety-fork spring (7). The primer (9) is now uncovered, but is held away from the striker by the striker spring (3). When the safety fork (8) is ejected from the fuze and the force of set-back is over, the set-back pellet spring (12) forces the set-back pellet (5) forward again, completely closing the opening left by the safety fork (8). This prevents any possibility of the flash from the primer (9) escaping out this opening and thereby insures ignition of the black powder (11) in the body (6). It also serves to prevent the escape of the explosion of the black powder (11) through this opening and thereby directs this explosion into the booster.

(*e*) Should the shell strike on its nose, the inertia of the sleeve (4) overcomes the resistance of the striker spring (3), and the sleeve slides over the striker (2), causing the primer (9) to strike the firing pin of the striker and explode. If the shell strikes on its base, the inertia of the striker (2) overcomes the resistance of the striker spring (3) and the firing pin of the striker is driven into the primer (9), exploding it. Should the shell strike on its side, or obliquely, the striker (2) and sleeve (4) are forced toward each other by the cone-shaped recesses in the upper cone cap (1) and the lower cone seat (10), and thus the firing pin of the striker is driven into the primer (9), exploding it. The flame from the explosion of primer passes through a hole in the lower cone seat (10) and explodes the black powder charge (11) in the body (6).

(*f*) The explosion of the black powder in the fuze sets off the detonator in the top of the booster which detonates the booster charge. This in turn detonates the bursting charge of the shell.

c. Propelling charge.—The propelling charge is similar for all types of ammunition. It consists of two main units—the cartridge, Mk. I, green in color and similar in appearance to a commercial shotgun shell, and the powder rings. The shell may be fired by using the cartridge alone or the cartridge and 1, 2, or 3 powder rings. This permits of four zones of fire, giving ranges

of from approximately 150 yards to approximately 750 yards. Zone 1 firing is conducted by using the cartridge only; zone 2, by using the cartridge and 1 powder ring; zone 3, by using the cartridge and 2 powder rings; and zone 4, by using the cartridge and 3 powder rings. The number of powder rings to be used is determined by the range desired, as stated in the range tables. Never use more than three powder rings, as excessive pressure will be developed which may burst the mortar. With the cartridge and 3 powder rings (zone 4) the pressure developed is within the working pressure of the mortar, but the use of this charge is recommended only in cases of necessity. The cartridge is placed in the cartridge container of the shell and the powder rings are placed over the cartridge container (fig. 9) just prior to firing. The powder rings should be placed over the vent holes in the cartridge container.

d. Preparation for firing.—To assemble the shell and prepare it for firing, it is necessary to fuze the shell and to attach the propelling charge.

(1) To fuze the shell, proceed as follows:

(*a*) Open the boxes and containers therein.

(*b*) Clean the shells, insuring that cosmoline is removed from the head and base and from the holes in the cartridge container.

(*c*) Unscrew the fuze-hole plug.

(*d*) Insert the booster in the booster casing, open (red-felt) end up.

(*e*) Place the leather washer on the fuze, seating it well above the threads.

(*f*) Screw the fuze firmly on the shell.

(2) To attach the propelling charge, proceed in the following manner:

(*a*) Insert a cartridge in the cartridge container.

(*b*) Place the necessary or ordered number of powder rings on the outside of the cartridge container.

21. Misfires.—*a.* A misfire is a shell which has been loaded into the barrel of the mortar but the propelling charge of which has failed to function. The shell therefore remains in the mortar until it is removed by hand. A misfire may be caused by the following conditions:

(1) Bad cartridge.

(2) Loose or bent anvil pillar in the mortar.

(3) Dirty shell guides.

(4) Dirty bore.

(5) Burst cartridge container or other fragments from previous rounds in the mortar.

(6) Bent or crooked cartridge container.

b. When a misfire occurs, No. 1 places his right leg behind the right leg of the mount, bracing it, and places his right hand, palm up, under the muzzle. No. 2 then lifts the base of the barrel until the shell slides slowly toward the muzzle. As soon as the shell has started forward, No. 1 places one or two fingers of his right hand over the muzzle and stops the shell when the tip of the fuze reaches the muzzle. He then ascertains the position of the safety fork and grasps the fuze so that the safety fork is held in place by the palm or fingers of his right hand. Keeping the palm or fingers of the right hand over the safety fork, he *unscrews the casing of the shell from the fuse* with his left hand. He then withdraws the shell from the barrel and passes the fuse and shell to No. 3, who replaces the safety pin and inspects the shell to determine the cause of the misfire. If the primer of the cartridge has been well and centrally struck by the anvil pillar of the mortar he removes the cartridge and inserts a new one. No. 2 unscrews the base cap, inspects, cleans, and tightens the anvil pillar. No. 1 inspects and swabs out the bore. The inspection and remedial action being completed, the mortar is assembled and firing continued.

CHAPTER 2

37-MM GUN AND THE 3-INCH TRENCH MORTAR MARKSMANSHIP

		Paragraphs
SECTION I.	General provisions	22–26
II.	Preliminary instruction; 37-mm gun	27–38
III.	Preliminary instruction; 3-inch trench mortar	39–45
IV.	Examination	46–51
V.	Qualification course; gunner's test	52–70
VI.	Qualification course; expert test	71–76

SECTION I

GENERAL PROVISIONS

22. Object of instruction.—*a.* The purpose of howitzer company instruction is to train the personnel to deliver a prompt and accurate fire at the command of the gun commander and to train the gun commanders to direct the placing of quick and effective fire on a target.

b. The final measure of the effectiveness of either howitzer company weapon in battle is its ability to destroy the targets assigned to it in a minimum of time.

23. Methods to be followed.—Organizations undergoing howitzer company training will follow the methods prescribed herein carefully and in detail. There remains a large field for individual initiative on the part of the organization commander in sustaining interest and enthusiasm within the organization. This object is usually best accomplished by conducting competitions, both in the preparatory exercises and range practice, between individuals, squads, and platoons; and by additional exercises along the general lines of those prescribed. Training in 37-mm gun and 3-inch trench mortar practice is not confined to the regular and supplementary seasons, but is carried on continuously throughout the year.

24. Duties of leaders and commanders.—*a.* The squad leader is held responsible that the equipment of the squad is at all times complete and in the best possible condition. During

the preliminary instruction he requires that all of the time of each man in his squad be fully occupied in some form of training for the qualification course. He requires each man to understand thoroughly every point of the qualification course tests, and endeavors to make each member of his squad at least a second-class gunner and as much higher in qualification as possible. During the preliminary instruction each squad leader examines the members of his squad at the termination of periods of instruction in the duties of No. 1, gunner, and observer (37-mm gun and 3-inch trench mortar) and notes their progress on the progress chart.

b. The platoon sergeant supervises the work of the squad leaders in his platoon.

c. The platoon leader supervises and directs the squad leaders in training their squads, and personally checks up each man in the platoon on the points required in preparation for the qualification course. In addition, the platoon leader conducts courses of instruction in the subjects covered in the company commander's certificate of proficiency.

d. The company commander requires the prescribed methods of instruction to be followed carefully and in detail, and supervises the work of the squad and platoon leaders. He should so conduct the training of the company that it will never fall below the minimum standard prescribed herein.

25. Duties of higher commanders.—The duties of higher commanders are similar to those exercised in connection with rifle marksmanship.

26. Grades and basis of qualification.—Soldiers in howitzer companies will be graded according to proficiency exhibited in the qualification courses for both the 37-mm gun and the 3-inch trench mortar, as expert gunner, first-class gunner, second-class gunner, and unqualified. The unqualified class includes those men on the rolls of an organization who have taken the qualification course and failed to qualify as second-class gunner, or better, and all others who for any reason have not been classified.

SECTION II

PRELIMINARY INSTRUCTION; 37-MM GUN

27. General provisions.—*a.* 37-mm gun firing is a mechanical operation which anyone who is mentally and physically fit to be a soldier can learn if properly instructed. Before taking instruction in 37-mm gun marksmanship the soldier will be thor-

oughly instructed in the gun drill of the 37-mm gun squad as contained in Basic Field Manual, Volume II, and in stripping, mechanism, care, and cleaning of the 37-mm gun as contained in Chapter 1. He will then be taught the mechanical operations to be employed in firing the gun. He will be taught these operations in their proper order and must be carefully coached.

b. The instructional exercises to be taken prior to qualification tests are prescribed below. They will be taken up in the order given, and each man must be proficient in one exercise before proceeding to the next. Each exercise should, if time is available, be repeated a number of times for the purpose of increasing the soldier's proficiency in it. The progress made by each man in the exercises hereinafter prescribed will be kept on record in the company on the progress chart shown below.

c. Permanent gunners and noncommissioned officers can be used to advantage in the preliminary instruction. Each of these more experienced men is assigned to conduct one exercise. Men being instructed then progress from one instructor to the next as their training develops. In this manner instruction is expedited and uniformity secured. The officer supervising the training assures himself that each instructor understands the exercise assigned him, is accurate in his explanations, and insists upon exact performance of the various details.

d. During the instruction in duties of individuals in the service of the piece special emphasis is placed upon the necessity for accuracy. The soldier is made to understand thoroughly that speed is purely a matter of practice, but that accuracy can be obtained only by forming the habit of exactness from the beginning. Rapidity is increased by insisting that each individual perform his duties in the prescribed sequence.

28. Duties of No. 1.—*a.* No. 1 is instructed that during firing he takes position on the right trail of the piece, and assists the gunner by loading, firing, and unloading the piece. Before being instructed in the technical duties of the gunner the soldier is taught to perform properly the duties of No. 1.

b. No. 1 is taught to be on his right side, with his hip resting on the right end of the trail brace and his right forearm resting on the trail. In all drills and practice he is required to lie as close to the trail as possible, so as to form the habit of doing so. By lying close to the trail he presents a small target and lessens the possibility of being observed by the enemy.

PROGRESS CHART

NAMES	Direct laying 37-mm gun sighting triangles	Direct laying 37-mm gun on target	Direct laying 37-mm gun change in fire data	Direct laying 37-mm gun on aiming point	Indirect laying 37-mm gun with first fire data	Indirect laying 37-mm gun change in fire data	Indirect laying 37-mm gun determining minimum range	Indirect laying 37-mm gun with lensatic compass

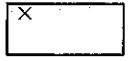
METHOD OF MARKING

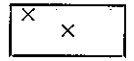
Fair	×		Good	×	×	Very good	×	×	×	Excellent	×	×	×	Excellent and has instructional ability	×	×	×	×	×

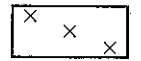
PROGRESS CHART

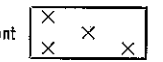
NAMES	Laying 3-inch trench mortar, digging pit	Laying 3-inch trench mortar for elevation and direction	Establishing direction with alidade, or lensatic compass, mortar position fixed	Establishing direction with aiming stakes, alidade or lensatic compass, mortar position not fixed

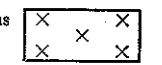
METHOD OF MARKING

Fair 

Good 

Very good 

Excellent 

Excellent and has instructional ability 

c. To load the piece, No. 1 is instructed to open the breech, grasp the cartridge by the rim with his left hand, insert the nose into the chamber and push it in with the first two fingers. He then closes the breech by placing the fingers of his left hand upon the breechblock lever and moving it to the right and down. The fingers do not grasp the breechblock lever, but remain upon it until it meets the shoulder which limits the movement of closing. The fingers are then allowed to slide off the breechblock lever, thus preventing it from rebounding when it strikes the shoulder, and insuring that the breech is fully closed. A simple demonstration will make it clear that the piece can not be fired unless the breech is completely closed. An empty cartridge case fitted with a pointed wooden projectile or an empty cartridge case crimped in at the top can be used to advantage in training men to load and unload rapidly.

d. No. 1 is taught to fire the piece by exerting steady pressure upon the trigger with the thumb of his right hand, at the same time steadying himself by resting his right forearm and hand on the trail. As soon as the piece is fired, his thumb is allowed to slide off the trigger. Unless this is done, the trigger crank will intercept the forward movement of the sear arm in counter-recoil, causing the sear head to be depressed and thus preventing the automatic cocking of the piece. It should be impressed upon the soldier being trained as No. 1 that he fires the piece only at the command of the gunner. During the interval between rounds, No. 1 keeps his thumb just above but not touching the trigger to prevent an accidental discharge which might result in injury to the gunner. As soon as the command to fire is given by the gunner, the piece will be fired immediately. Both No. 1 and the gunner remain steady on the trail, and both remain motionless just before firing, as any movement at this time will decrease the accuracy of the fire.

e. To unload, No. 1 is taught to open the breech with his left hand, placing his fingers under the breechblock lever and giving it a quick jerk upward and to the left, with sufficient force to throw the empty case clear of the gun. His fingers do not grasp the breechblock lever because this would slow up the movement and might cause the gunner, who has his eye to the sight, to be struck in the head by No. 1's hand.

29. Duties of the gunner.—The gunner is instructed that during firing he takes position on the left trail and lays the

piece in accordance with firing data received from the observer. In addition to being familiar with the details of laying for direct and indirect laying, the gunner should understand the use and proper selection of aiming points, be able to determine the least range at which the piece may be fired and clear the mask, understand the practical methods of safely employing fire over friendly troops, and understand the proper manner of laying on a moving target on the ground.

30. Training of the gunner; position at the gun.—The gunner is taught to lie on his left side, with his left hip resting on the left end of the trail brace and his left forearm resting on the trail. In laying the piece he grasps the elevating handwheel with his left hand and the traversing handwheel with his right hand. He keeps this hold when the piece is fired in order to maintain the proper laying and prevent undue displacement from the shock of recoil. This precaution also reduces the time necessary to relay for direction and elevation. While the gunner is being trained to lay, he is not, at first, required to hold his eye close to the sight during firing. By keeping his eye a few inches in rear of the sight at first, the gunner will be able to eliminate a natural tendency to flinch when the piece is fired, and with a little practice will become accustomed to remaining entirely motionless on the trail during firing. A gunner who flinches is very apt to move the elevating and traversing handwheels and to jar the mount. The gunner soon becomes accustomed to the explosion and the recoil of the gun, and gradually learns to hold his eye nearer to the sight until he finally discovers that position for his eye which secures accuracy, speed, and safety.

31. Training in direct laying.—The telescopic sight is set for range and deflection in the manner described in Part Two.

a. Sight-setting exercises.—In his first instruction in the setting of the telescopic sight the gunner is given the sight to hold in his hand. He sets off ranges and deflections commanded by the instructor, who checks each setting before commanding the next. The sight is then placed on the gun and further practice is given the gunner in setting off range and deflection.

b. Aiming with telescopic sight.—Accurate shooting can not be done unless the crosslines are laid on exactly the same point for all shots. The better defined this aiming point is the easier it is for the gunner to relay on the same point. During a recruit's first instruction in aiming he is taught to aim at

clearly defined points. To this end a small paster about 2 inches square is placed on a screen about 25 yards in front of the gun. The instructor lays the gun by aiming at the paster. In aiming at the paster the intersection of the crosslines is laid upon one corner of the paster in such a manner that two sides of the paster coincide with the crosslines in one quadrant of the field of the telescope. The instructor explains that either quadrant may be used for the first laying and points out the necessity for placing the paster in the same quadrant of the field of the telescope in all subsequent laying on the same aiming point. The gunner is then required to aim at this point several times, the instructor checking the aim each time. When the recruit has become proficient in aiming at pasters he is taught to aim at stakes, posts, poles, and larger objects. In aiming at such objects the crosslines are placed so that the vertical line coincides with one edge of the object and the horizontal line coincides with the top, bottom, or some distinguishable mark on the object. The recruit is taught next to aim at natural targets, such as small bushes, light and dark colored patches on the ground, and small features of the terrain that are readily distinguishable. In aiming at such targets the recruit must be impressed with the importance of selecting for his aiming point that part of the target on which he can most easily and quickly relay the crosslines after fire is opened. The gunner, therefore, should place the crosslines upon the most clearly defined part of the target, whether it is the top, bottom, center, or side. (Fig. 11.)

c. Using an aiming point other than the target.—When the gunner has been trained to use the target as an aiming point, he is next taught how to use an aiming point other than the target when the target does not offer a suitable aiming point. This method is described in paragraph 77 *c*. To impress the gunner with the necessity and importance of using a clearly defined aiming point instead of laying upon an indistinct target, he is required to lay upon an indistinct target, throw the line of aim off, and relay upon the target several times. This exercise will illustrate the difficulty of picking up an indistinct target. The instructor also emphasizes the fact that the smoke and dust caused by bursting shells make the target even more indistinct. After the reason for using an aiming point other than the target has been illustrated, the gunner is taught that he can quickly lay the gun to hit the target by aiming at any

well-defined point near the target. The first step is to lay the intersection of the crosslines upon the target with zero deflection and the range to the target set on the sight. Then, by turning the deflection and range dials, the intersection of the

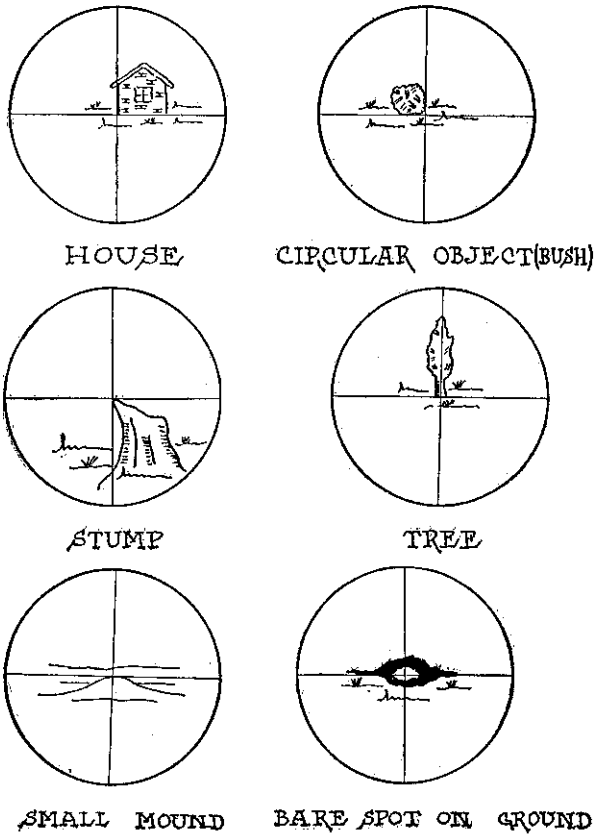


FIGURE 11

crosslines is moved to the selected aiming point and the gunner then calls out the new range setting on the sight. The gunner is given exceptionally thorough instruction in this method because it is frequently used in combat. Having been shown the necessity for using such an aiming point and in-

structed in the mechanical method of using one, the gunner is given practice in the selection of aiming points for various indistinct targets pointed out by the instructor.

32. **Training in indirect laying**—*a. Sight-setting exercises.*—The gunner is trained how to set off range, deflection, and angle of site with the quadrant sight in a manner described in Part Two. The gunner is instructed to set the quadrant sight by the methods of instruction described in paragraph 31*a*.

b. Laying for direction with quadrant sight.—(1) When the quadrant sight is used for indirect laying, the gun is laid for direction, but not for elevation, by aligning the vertical line in the quadrant sight upon some aiming point in the same manner as the vertical crossline in the telescopic sight is aligned. (Fig. 11.)

(2) The gunner is first instructed in laying the vertical line of the collimator upon the simplest form of aiming point, as, for instance, a vertical stake about 25 yards in front of the gun. The instructor first lays the gun and then requires the gunner to look through the sight. The gunner is then required to lay on the stake, repeating the operation several times until proficient. In laying upon such an aiming point one edge of the stake is used.

(3) The gunner is next taught to use other aiming points which present a vertical line upon which the vertical line of the collimator can be laid. Such aiming points are houses, poles, and trunks of trees. In using a house as an aiming point the edges of the chimney, sides of the windows, or the corners of the house are used in the same manner as the edge of a stake.

(4) The gunner is shown that deflection can be uniformly measured from any point on a vertical line, but that deflection measured from different points on an inclined line will vary. The gunner, therefore, is trained to pick out vertical lines as aiming points for direction and to lay the vertical line of the collimator upon them. The instructor checks the gunner's aim to see that he has selected a proper aiming point and that he has laid accurately upon it.

(5) It will often happen that aiming points which present vertical lines upon which to lay the vertical line of the sight can not be found. For this reason the gunner is next taught to lay the vertical line upon a point. To do this the gunner lays on the aiming point by placing the vertical line of the collimator on the aiming point. Aiming points used in this instruction

should at first be small pasters placed on a screen in front of the gun. When the gunner has become proficient in laying on a paster, he is given practice in laying upon small natural objects.

(6) The next step in training the gunner to lay for direction by means of the quadrant sight is to practice him in selecting and laying upon aiming points on large objects, such as buildings, trees, and bushes. He is called upon to select that point on such an object which makes the best point upon which to lay the vertical line of the collimator. The instructor checks the gunner's aim to see that he has selected the most clearly defined point upon which to lay and that he has laid accurately upon it.

(7) The gunner is now taught how to provide a suitable aiming point for use in maintaining direction when the piece has been previously laid for direction. In teaching this method the instructor lays the piece for direction and tells the gunner that the piece is laid in the proper direction to hit the target but that the sight is not aligned upon any aiming point. He then tells the gunner to align the sight upon some aiming point which may be used to maintain the direction of the piece during firing. The gunner then selects a suitable aiming point, preferably a well-defined natural object on the ground to the front, and aligns the vertical line of the collimator upon it by means of the range and deflection dials. He does not move the traversing handwheel during this operation, as doing so will move the gun barrel from the proper direction to hit the target. Should the gunner not be able to find a suitable aiming point on the ground within the limits of movement of the deflection dials, he places a stake or other object in such position that it can be used as an aiming point. An ammunition box, a stone, or a piece of paper or cloth weighted down can be used. The gunner directs the placing of this aiming point a short distance in front of the gun in such position that the vertical line of the collimator can be brought upon it without changing the direction of the barrel. The gunner then aligns the vertical line upon this aiming point as before by means of the range and deflection dials. In the firing of successive rounds the gunner relays for direction each time by aligning the vertical line on the aiming point by means of the traversing handwheel.

c. Laying for elevation.—When the gunner has been taught to lay the piece for direction, he is taught to lay the piece for elevation. The instructor announces the angle of site and range

to be set off on the sight by the gunner. The instructor explains that the setting off of the angle of site and range does not move the axis of the bore, and that the next and last step in laying the gun for elevation is to center the bubble by means of the elevating handwheel. The instructor drills the gunner in laying the gun for elevation for different angles of site and ranges until he is found to be proficient.

d. Determination of minimum range.—This operation is a mechanical one and the gunner will be made proficient in performing the operation before any attempt is made to explain to him the reasons for the various steps. The gun is set up behind a crest or behind any artificial object which may simulate a crest. The gunner is told that he can determine the least range at which he can fire over the crest from a given gun position with a given angle of site by the following steps:

(1) Set off the range to the crest on the range dial with the angle of site dial set at zero.

(2) Lay the gun by turning the elevating screw handwheel so that the horizontal crossline in the collimator just clears the top of the mask.

(3) Center the bubble by means of the range dial.

(4) Set off the angle of site of the target on the angle-of-site dial and read the minimum range on the range dial opposite the index on the angle-of-site dial, and announce the minimum range to the gun commander. The gunner is drilled in performing these four steps, which comprise the operation of determining the minimum range, until they become mechanical with him. This operation is quite different from laying the piece in indirect laying, yet the beginner will often confuse the two. For this reason the gunner will not be given instruction in determining the minimum range until he is thoroughly familiar with the methods of laying the piece. When the gunner has become proficient in the method of determining the minimum range, he is made to understand thoroughly its application in firing. He must realize that the minimum range is the least range which he can set off on the range dial and fire over a mask from a certain gun position as long as he uses the same angle of site on the angle-of-site dial as he used in determining the minimum range. He must also realize that when the gun commander announces a new angle of site or when the gun is moved to a new position he (the gunner) must find the new minimum range. He will also be taught to announce to the gun

commander the minimum range immediately after it is found. He will further be instructed that he is to notify the gun commander when a range less than the minimum range is announced in a fire order. When the gunner has a thorough understanding of the above method he may be taught how to find the minimum range by the shortest method for the same gun position for a new angle of site. This method consists of setting off the angle of site used in first determining the minimum range on the angle-of-site dial, setting off the minimum range first found on the range dial opposite the index on the angle-of-site dial then, without moving the range dial, setting off the new angle of site and reading the new minimum range on the range dial opposite the index on the angle-of-site dial.

33. Execution of fire orders.—After the gunner has been taught to lay the gun properly for direct laying, he is drilled in executing fire orders of the nature of those described in paragraph 80*a* until he can lay the gun with speed and accuracy. Men are taught to execute fire orders for indirect laying in a like manner.

34. Duties of the observer.—*a.* It is the duty of the observer to direct the gun squad in placing prompt and effective fire upon a target. He obtains the firing data for the first shot for the purpose of placing the first shot upon the target, or as near to it as possible, in a minimum of time. During the firing he observes each burst and gives to the gunner the corrections in deflection and range necessary to bring the fire upon the target. The observer keeps himself informed of the position of friendly troops, and when fire is to be delivered over their heads he is responsible that no firing is ordered which endangers them. When range cards are necessary, he prepares them for the positions of his gun.

b. During firing the observer maintains a position from which he can see the target and be in communication with the crew at the gun. When direct laying is employed his position is at or near the gun, and his orders are given to the gunner by voice. When, in indirect laying, it is necessary for the observer to be at a short distance from the gun in order to see the target, he uses the simplest and most direct method of communicating with the gun crew. This method is by voice directly to the gunner. The next best methods are by visual signals or by voice, with a man stationed between the observer and gun repeating the fire orders. If it is not possible to use either of these methods,

communication is maintained by runner or by mechanical means, such as the buzzer or telephone. The essential rule is that the more simple and direct the means of communication, the more prompt and effective will be the fire, and that if communication between observer and gun is interrupted the weapon becomes useless.

35. Training of the observer, direct laying—*a. General.*—When a soldier has been found proficient in the duties of gunner he is instructed in the duties of the observer. The first step in the training of the observer is the method of obtaining the firing data for direct laying. It is here that training in the estimation of ranges is given. Instruction in target designation is also given for the purpose of enabling the observer to give to the gunner the firing data which have been found.

b. Training in the preparation of range cards.—Range cards are constructed as described in paragraph 82. The men are divided into squads under noncommissioned officers and taken to suitable terrain. The officer in charge explains to the men the method of constructing range cards, requiring the men to perform each step of the work as he describes it. Noncommissioned officers supervise the work of their squads, pointing out any mistakes and requiring the men to correct such mistakes before proceeding with their work. The men are then required to construct a range card of the same terrain without help from the instructor. The instructor collects these cards, points out any mistakes in them, and requires the men to correct these mistakes. This operation is repeated until the men are considered proficient.

c. Determination of ranges.—In combat the exact range required to hit a target will seldom be known prior to the opening of fire, and a material saving of time and ammunition can be effected by accurate range estimation. If fire is opened with an incorrect sight setting, the position of the gun is often disclosed before fire falls on the target, thus increasing the probability of casualties in the gun crew; ammunition is wasted and overhead fire may be rendered unsafe.

(1) *Methods of determining ranges.*—The usual method of range determination used with the 37-mm gun and 3-inch trench mortar in combat is estimation by eye. Other means may be used, but the main reliance must be placed on estimation by eye. Range finders are bulky, require trained observers, and must be kept in accurate adjustment. Measurement on the ground

is practicable only in specially prepared defensive positions and in the absence of the enemy. Accurate maps are good, but require more time than is usually available. Ranges may be secured from other troops, particularly when making a relief.

(2) *Necessity for training.*—(*a*) As estimation by eye must be depended upon in combat, all men, and especially gun commanders, should be trained in this method. Stress should be laid on estimating ranges between 600 and 1,400 yards.

(*b*) The estimation by eye of untrained men is little better than a guess, and the average errors of such men will be at least 12 per cent of the range. A definite system of range estimation, frequently practiced, is the only way to make estimation by eye sufficiently reliable.

(3) *Method of estimation by eye.*—(*a*) Estimation by eye consists in measuring the range by applying to it a unit of measure 100 yards long. The method is the same as that employed in measuring the length of a board with a ruler. The only difference is that the soldier's unit of measure is applied mentally. Thorough familiarity with the 100-yard unit and its appearance on different kinds of ground and at different distances will enable the estimator to apply it with a fair degree of accuracy.

(*b*) Knowledge of terrain, life in the open, and training in scouting and patrolling are helpful in range estimation.

(*c*) Application of the unit of measure beyond 500 yards is difficult. For this reason, in ranges over 500 yards, it is better to select a point halfway to the target, apply the 100-yard unit up to this halfway point, and multiply the estimated distance by two.

(*d*) The average of a number of estimates by different men will generally be more accurate than a single estimate. However, in combat the gun commander must usually rely on his own estimation.

(4) *Conditions affecting the appearance of objects.*—(*a*) Conditions of light and terrain have considerable effect upon the appearance of objects, making them seem sometimes much nearer and at other times much more distant than they really are. The effect of these conditions on the appearance of the 100-yard unit of measure is negligible.

(*b*) In some cases much of the ground between the observer and the target will be hidden from view and the application of the unit of measure to the hidden portion of the ground will be impossible. In such cases the appearance of objects is the only guide.

(*c*) If there is a considerable stretch of visible ground extending from the far edge of the depression to the target it is best to estimate the distance to the far edge of the depression, judging by the appearance of objects, and then to apply the unit of measure over the remaining distance to the target.

(*d*) Whenever the appearance of objects is used as a basis for range estimation the observer must make allowance for the effects noted below:

1. Objects seem nearer—

(a) When the object is in a bright light.
(b) When the color of the object contrasts sharply with the color of the background.
(c) When looking over water, snow, or uniform surface like a wheat field.
(d) When looking from a height downward.
(e) In the clear atmosphere of high altitudes.
(f) When looking over a depression most of which is hidden.

2. Objects seem more distant—

(a) When looking over a depression all of which is visible.
(b) When there is a poor light or fog.
(c) When only a small part of the object can be seen.
(d) When looking from low ground toward higher ground.

(5) *Exercises.*—For exercises for training in range estimation, see Chapter 6, Part One, Basic Field Manual, Volume III.

d. Field glass and range table method.—The observers are taught how to obtain the firing data necessary in indirect laying when an aiming point other that the target is used by means of the field glass and range table method. To do this the observers are trained in measuring angles with the horizontal and vertical mil scales in the type EE field glass. The instructor draws a rough diagram of the horizontal and vertical mil scales as they appear in the field glasses and gives a brief explanation of their use. He then stations the observers with field glasses about 25 yards from a blank white panel or the side of a building. He makes two marks of the same height on the panel and requires each observer to measure the horizontal angle between the two points. He checks their readings with his field glass, or by the use of the mil formula, since he knows the distance from the observers to the target and the distance between the two marks. The instructor then makes two marks

on the panel, one above the other, and requires the observers to read the vertical angle between the two points. This is checked in the same manner as the horizontal angle. Care must be taken that the men use the mil scale in reading the vertical angle rather than the inverted sight leaf which is found in the field glasses. The observers are then instructed in the use of the angle of departure table in the determination of the range to be used when laying upon an aiming point above or below the target. This method is described in paragraph 77*c* (2). The instructor may give preliminary instruction in the use of this method by making two marks (one to represent the aiming point, the other to represent the target) on the panel which vary both in direction and elevation. He gives the observers an assumed range to the target as represented by one mark and requires each observer to compute the firing data necessary to use the aiming point represented by the other mark.

36. Indirect laying; methods of obtaining direction—*a. General.*—The various methods of obtaining the direction for indirect laying are described in paragraph 78. The observer is first taught the simplest and most commonly used methods. Later he may take up the more difficult methods. To comprehend the methods of obtaining direction by compass the observer is given training in the use of the lensatic compass, as prescribed in Chapter 1, Part Two, Basic Field Manual, Volume III. The observer is given considerable practice in the use of the compass, both in reading and setting off magnetic azimuths, before he can be considered proficient.

b. Determination of the angle of site.—The first step in training an observer to determine the angle of site is to teach him to determine the horizontal. This is done indoors or on level ground which may be found adjoining the barracks. The instructor requires each observer receiving instruction to place a mark on the wall at the height of his eye. Each observer stands facing his mark on the wall at a distance from the wall of 10 yards, or more if possible. He raises his extended arm, wrist straight, palm down, and fingers extended and joined, until the tips of the fingers are the same height as the mark on the wall. The tips of the fingers then indicate the level of the observer's eye. The observer repeats this step several times. He then practices locating the level of his eye without the mark, which is covered by another man until the observer has located what he believes to be the level of his eye. After repeating this opera-

tion several times and checking each time by means of the mark the observer is ready to proceed to the next step. He is then taken to a position affording a good view of the terrain and is required to indicate different points on the ground to the front which he believes have the same elevation as his position. The elevations of these points are checked by the instructor using an angle-of-site instrument. When the observer has been given a few trials in the selection of these points and has shown a fair degree of accuracy in them, the method of obtaining the angle of site described in paragraph 78 is explained to the observer and he is practiced in using it. Only a few minutes' daily practice for several days is necessary to train an observer to estimate the angle of site with sufficient accuracy. If no angle-of-site instrument or other instrument designed for the measuring of angles of site is available, the point on the ground in front or in rear of the target having the same elevation as the gun position is found by means of the quadrant sight on the gun as follows: Set the angle-of-site dial and range dial at zero and center the bubble by means of the elevating handwheel. The horizontal crossline is then laid upon all points in the field of the sight having the same elevation as the gun position. This method can be used by the instructor in training observers to estimate the angle of site but can not be used in action. The angle-of-site instrument is not issued to the gun commander for use in the field, the estimation of the angle of site by a trained observer being sufficiently accurate for the firing of the first round. The use of the angle-of-site instrument is confined to the training of the observer.

37. **Fire control; fire orders.**—The observer is trained in giving fire orders while other men are being trained in the duties of gunner. The fire order must be given in the prescribed sequence, in order to avoid errors on the part of the gunner, and the different parts must be given at sufficient intervals to enable the gunner to set off the data on the sight as they are given. The observer will require the gunner to repeat the fire order correctly, step by step, as it is given.

38. **Adjustment of fire.**—The observer is taught to adjust fire after he has been found proficient in the preceding subjects. Good results can be obtained by training a group of observers at the same time. Observers are stationed at observation posts and required to make corrections for errors in deflection and range in adjusting fire upon a target. The bursts of projectiles

are simulated by exposing panels, waving flags, or by throwing up small quantities of powdered material (slaked lime, dry earth, or sand) in the area surrounding the target. The following-described method will be used in training personnel in the adjustment of 37-mm fire. All the equipment may be easily improvised at any post, and if the terrain and materials are at hand the system can be elaborated.

a. Arrangement of terrain.—(1) Terrain should be selected so that estimation of errors in range and deflection should not be too easy. The target and the gun position are first selected. They should be separated by at least 500 yards. Observation posts are located, one on the line gun-target and one on the flank, at least 100 yards, in order to insure proper training in these two conditions of fire adjustment. Both posts should be at least 500 yards from the target.

(2) The area surrounding the target is staked off as follows: Commencing at the target, stakes are driven at 50-yard intervals on the line gun-target on both sides of the target. A perpendicular to this line is constructed at the target by means of a compass or carpenter's square, etc., and stakes are driven on this line at 10-yard intervals both to the right and left of the target. Parallel lines of stakes are then laid out on these base lines thus established until the area is staked out as shown in the instructor's chart. (Fig. 12.) The stakes are then numbered and strips of colored cards tacked on them according to the code shown on the instructor's chart. The target is set up to be plainly visible from the observation posts.

b. Arrangement of personnel.—The personnel operating the system is posted with panels, flags, or buckets of puff-producing materials and other signal equipment as shown in the instructor's chart, and functions as follows:

(1) One man at observation post near instructor. Transmits signals as directed by the instructor.

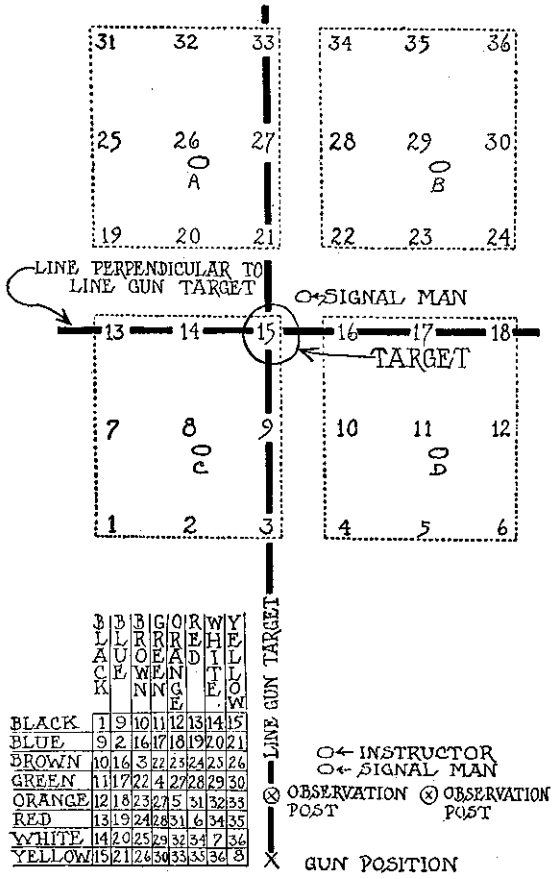
(2) One man near target. Relays signals from the observation post to men posted at stakes.

(3) Four or more men distributed around staked area. As shown on instructor's chart, these men simulate bursts as they are designated by signals. In the system as shown on the instructor's chart each man operates nine stakes.

c. Equipment.—The following equipment is required:

(1) Thirty-five stakes. The stakes may be constructed from packing boxes, crating, limbs of trees, etc. They should be

tall enough to be clearly visible to the grenade thrower from his position.



	BLACK	BLUE	BROWN	GREEN	ORANGE	RED	WHITE	YELLOW
BLACK	1	9	10	11	12	13	14	15
BLUE	9	2	16	17	18	19	20	21
BROWN	10	16	3	22	23	24	25	26
GREEN	11	17	22	4	27	28	29	30
ORANGE	12	18	23	27	5	31	32	33
RED	13	19	24	28	31	6	34	35
WHITE	14	20	25	29	32	34	7	36
YELLOW	15	21	26	30	33	35	36	8

FIGURE 12.—Instructor's chart

NOTE.—A, B, C, and D indicate men posted to simulate shell bursts at their respective stakes.

(2) Target. Any object may be used which is conspicuous from the observation posts. Landmarks (such as a tree, trench, etc.) or a strip of target cloth are satisfactory.

(3) Two sets of signal panels. The panels are 15 by 15 inches, with the following colors in each set: Black, blue, brown, green, orange, red, white, yellow. They should be colored on both sides. In case a certain color can not be obtained some distinctly shaped panel or object, such as a hat, rifle, coat, etc., may be substituted. If desired, two sets of numerals—0, 1, 2, 3, 4, 5, 6, 7, 8, 9—may be used in place of colored panels. The wigwag or semaphore system may also be used.

(4) One instructor's chart. Constructed as shown in Figure 12. Should be mounted on board.

d. Procedure.—(1) The four (or more) men operating the stakes are given sufficient puff-producing material, panels, or flags and are stationed in the center of their stakes. When a color or combination of colors is flashed from the observation post or relay station the man whose stake has been signaled simulates a shell burst at the stake bearing that color.

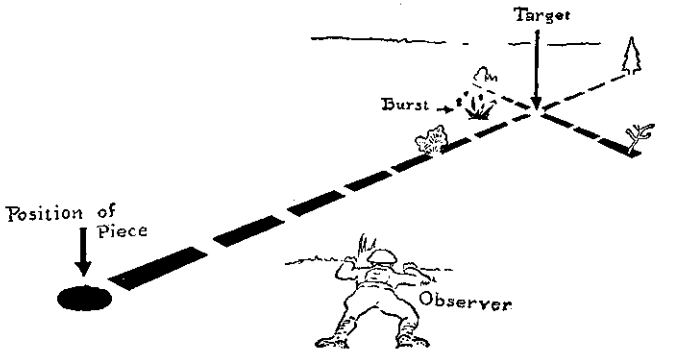


FIGURE 13

The observer from the flank visualizes the line gun-target and the line perpendicular thereto running through the target, by selecting objects on the terrain which appear to be on these lines. He then observes the burst for a "short" or an "over" and reads the error in deflection, doing both with reference to these lines.

(2) The signalman at the relay station near the target is equipped with a complete set of signal panels and a copy of the code on instructor's chart. He repeats the signal from the observation post, so that it is plainly visible to the men at the stakes.

(3) The signalman at the observation post is equipped with a set of the signal panels and the code on the instructor's chart. When the instructor calls a number, he consults the code and flashes the appropriate signal.

e. Adjustment of fire exercises.—(1) The instructor conducts the observers to an observation post on or near the line gun-target and points out the gun position and target. He points out the line gun-target by calling for bursts at points along that line; for example, bursts at 3, 9, 15, 21, 27, 33. (Fig. 12.) He then calls for a line perpendicular to the line gun-target in a similar manner; for example, bursts at 13, 14, 15, 16, 17, 18. (The marking of these lines in this manner is done to assist the observers in locating on the ground the line gun-target and the perpendicular thereto by means of landmarks in the vicinity of the target. These lines assist the observers in their observation of errors, since errors in deflection are estimated from the line gun-target once it is located on the ground, and likewise "shorts" or "overs" in range, when observed, are determined by the position of the bursts with respect to the line perpendicular to the line gun-target. These two imaginary lines are visualized by a trained observer immediately upon taking post at his observation station.) (Fig. 13.) Observation of the error in deflection must be made immediately upon the burst of the projectile if accurate readings are to be obtained, because the small puff of smoke soon vanishes or is moved by the wind. If the observer has his field glass at his eyes when the burst occurs, he will have no trouble in getting an accurate reading. It is also important that the observer be trained to make full corrections for errors in deflection until a hit is obtained upon the target, since the probable error of the gun at any except long range is quite small. The group under instruction is taught to make observations from a point near the gun position where the actual errors in deflection will appear as they are read with the field glass. For example, a burst is called up at No. 14 and the error read. The class is later taken from the gun to positions along the line gun-target to the front and rear of the gun and then to a flank and bursts called up at No. 14 again, to demonstrate that the corrections must be made for the difference in the size of the observed error in deflection and the actual deflection to be set off on the sight, depending on the position of the observer. (Par. 80 *d.*) To train the observers to determine

whether a burst is short of or beyond the target, a burst is called up at stakes very near the target and the observers required to state whether the burst was an "over" or a "short." For example, a burst might be called up at No. 9 stake to illustrate a "short." Then observation is made more difficult by calling for bursts at some distance to the right or left of the target but close to the line perpendicular to the line gun-target. For example, a burst might be called up at No. 24 stake. To instruct the observer to correct errors in range properly, the bracketing method of adjusting fire is then taught. Observers are given an assumed initial range for firing the first round and bursts are called up and observers required to use the bracketing method as given in paragraph 80. After the observers have become thoroughly proficient in adjusting fire by the bracketing method they may be trained to adjust fire by the creeping method. After thorough instruction in the methods for correction of errors in range and deflection, exercises are conducted combining observation and correction of these errors and incorporating the necessary corrections in a fire order. The procedure is as follows: The instructor points out the gun and target and requires the observers to compute the initial firing data for engaging the target. He then calls upon one of the observers to issue his fire order and calls for a burst at one of the stakes which is approximately the same distance from the gun as the range mentioned in the fire order. For example, assume this range was 750 yards and that when stakes 31, 32, 33, 34, 35, 36 were laid out they were approximately 750 yards from the gun position. Therefore the instructor may call up a burst at any one of these stakes. When the burst appears he requires the observers to estimate the error in range and deflection and calls upon one observer to issue a fire order to correct these errors. For example, assume the instructor called for a burst at No. 32 stake. If the observer estimates the error in deflection correctly and observes the burst to be over, his fire order would be "Right 25, 550, one round," and the instructor would call for a burst at No. 9 stake. If the observer again observes the burst correctly, his next fire order will be "650, one round," and the instructor calls for a burst at No. 21 stake. The next proper correction would be "600, one round," and the burst would be called for at No. 15 stake—the target. In the event that a fire order given by an observer contains an improper cor-

rection, the instructor calls for a burst in accordance with the data contained in the incorrect fire order, in order to demonstrate the errors. For example, had the observer given the fire order "Right 50, 550, one round," instead of "Right 25, 550, one round," in the preceding example, the instructor would have called for the burst at No. 10 stake. For the first round in subsequent exercises the first burst is placed at any stake the instructor selects. The instructor announces an assumed range at which this round was supposed to have been fired to the observers and requires them to adjust fire from there on.

(2) In the event that telephone communication is available between the observation post and the relay station, the number of the stakes at which the burst is desired may be transmitted to the relay station and serve as a check on the signal from the observation post. With good telephones the signal panels at the observation post may be dispensed with.

(3) Better results will be obtained where the orders can be communicated to the men at the stakes without the observers hearing the command or seeing the signal. In this way the observers will not be able to interpret the code used, which they may otherwise be able to do after having participated in a number of exercises.

(4) The training in fire adjustment may be combined with exercises in giving fire orders and laying the guns. The guns are put in action at the gun position and simulate opening fire. Subsequent changes in range and deflection are laid on the gun as estimated by the observer.

f. The observer's training can not be considered complete without actual firing. However, observers should not be given actual firing until they have demonstrated satisfactorily in the preceding training method that they are fully acquainted with the correct methods of fire adjustment.

SECTION III

PRELIMINARY INSTRUCTION; 3-INCH TRENCH MORTAR

39. General provisions.—*a.* Before taking instruction in 3-inch trench mortar marksmanship the soldier is thoroughly instructed in gun drill, 3-inch trench mortar squad, contained in Basic Field Manual, Volume II, in mechanism, care, and cleaning of the 3-inch trench mortar, and ammunition. He is then taught the mechanical operations to be employed in firing

the gun. He will be taught these operations in their proper order and will be carefully coached.

b. Permanent gunners and noncommissioned officers can be used to advantage in the preliminary instruction. Men being instructed are formed into squads under these more experienced men who will give them individual instruction in the work being performed. The officer supervising the training will assure himself that each instructor understands the various steps of the training, is accurate in his explanations, and insists upon exact performance of the various details.

c. During the instruction emphasis will be placed upon the necessity for accuracy. The soldier will be made to understand thoroughly that speed is purely a matter of practice, and that accuracy can be obtained only by forming the habit of exactness from the beginning. Rapidity is increased by insisting that each individual perform his duties in the prescribed sequence.

40. Training in digging base-plate pit.—*a.* The men to be trained are conducted to the place of exercise and formed in such a manner that all men can clearly see the place where the demonstration is to be given. A selected squad of qualified men then dig a base-plate pit as described in Basic Field Manual, Volume II, and paragraph 17. The squad first constructs the most simple type of base-plate pit, without sandbag reinforcement, and works slowly, performing each step of the construction of the pit distinctly. The officer in charge of the test explains each step in detail as it is performed by the demonstration squad. This demonstration will be repeated as often as is necessary until all men understand the proper method of constructing a pit.

b. The men are formed in squads under noncommissioned officers and required to construct base-plate pits. They work slowly at first and do not try to increase their speed of execution until they are thoroughly familiar with each movement of construction. The noncommissioned officer in charge of each squad closely supervises the work of the squad, pointing out any mistakes that may occur, and requiring the squad to correct such mistakes before proceeding in their work.

c. When all men are proficient in the construction of the simple type of base-plate pit, they are reassembled and the demonstration squad demonstrates the proper manner of reinforcing the base plate with sandbags as described in paragraph 16,

following the same method of demonstration as described in *a* above.

d. The men are then formed in squads and required to construct complete pits. No attempt will be made to gain speed of execution until familiarity with each movement is attained.

41. Training in the methods of obtaining direction.—The various methods of obtaining the direction are described in paragraphs 78 and 84. These methods are taught in the sequence prescribed therein. They should be taught first by demonstration and then by requiring each man to perform the work.

42. Training in laying the mortar for direction and elevation.—*a.* The men will be conducted to the place of exercise and arranged in such a manner that all men can clearly see the demonstration. A selected squad then demonstrates the proper method of laying the mortar for direction and elevation, performing each step of the method slowly and distinctly. The officer in charge of the training explains each step as it is performed. The demonstration is repeated until each man clearly understands each step of the procedure.

b. Each man is required to lay the mortar for direction and elevation until he is considered proficient. The noncommissioned officers point out all mistakes that are made and require the men to correct such mistakes before proceeding with their work.

43. Methods of teaching range estimation.—Range estimation is taught in the preliminary instruction for the 37-mm gun. Men who are proficient in estimating ranges for the 37-mm gun will experience no difficulty in this subject with the mortar, since the ranges used are considerably less.

44. Training in preparation of range cards.—Range cards are prepared and training in their preparation is conducted as for the 37-mm guns.

45. Training in fire adjustment.—The same method for training men in adjustment of 37-mm gun fire will be used in training men to adjust the fire of the 3-inch trench mortar, with the exception that the methods for adjusting fire prescribed in Section II will be followed. In preparing the terrain for 3-inch trench mortar fire adjustment exercises, more satisfactory results will be obtained if the distances between the stakes be shortened to 25 yards instead of 50 yards. The intervals between stakes may also be increased to 15 or 20 yards if desired.

SECTION IV

EXAMINATION

46. Place and date of examination.—Examinations will be held once each year to determine the proficiency and qualification of personnel under instruction. These examinations will be held where the company is serving and at a time least interfering with field training, the date being designated in conformity with these regulations by the commanders who convene the boards.

47. Examining boards; appointment and constitution.—The examination will be conducted by a board of three or more officers, not more than one of whom is a member of the same company as the man being tested. One member of the board, whenever possible, will be an officer serving with the howitzer company. Boards will be appointed by the commanders having authority to issue qualification orders as provided in AR 35–2380.

48. Subjects of examination—*a. Gunner's test.*

Subjects	Value
(1) Direct laying, the 37-mm gun	100
(2) Indirect laying, the 37-mm gun	100
(3) Laying the 3-inch trench mortar	100

b. Expert test.

(1) Range cards	100
(2) Computation of firing data for the 37-mm gun	100
(3) Individual field firing, 37-mm gun	100
(4) Individual field firing, 3-inch trench mortar	100

49. General rules governing examining boards.—The following rules will govern the examining boards:

a. The conditions of the examination will be made, as nearly as possible, equally difficult for all candidates. The board will be held responsible that no data obtained by a candidate during a particular test are transmitted to any other candidate who is to take that test under identical conditions; also that no candidate shall receive the benefit of any sight-setting or laying of the weapons, as left by a previously tested candidate.

b. Setting of scales on the 37-mm gun will be considered correct if any part of the index is coincident with any part of the line of graduation of the setting ordered.

c. Settings ordered by the board in the tests of the 37-mm gun will always be even divisions of the scale and not fractions thereof.

d. The candidate is permitted to traverse the 37-mm gun to the middle point of traverse before each trial at direct or indirect laying.

e. The telescopic or quadrant sight will be in position on the 37-mm gun before the command for any trial with it is given, the scales being set at zero at the beginning of each test.

f. Changes in setting of scales required of candidates in the tests on the 37-mm gun will not exceed the following: Deflection scale, 20 mils; range scale, 600 yards. At no time during a trial will any setting or change be ordered which requires a sight setting beyond the limits of the scale. During trials requiring the use of the spirit level the level bubble will be thrown out of center after each trial.

g. Should any candidate fail in any trial through the fault of an examiner or an assistant, or of the sight or other instrument used, that trial will be void and the candidate immediately given another trial of the same nature.

h. The candidate may select the assistants authorized.

i. Each candidate will be given the tests on each weapon in the order in which they are described herein, but any candidate may be tested in either weapon first, at the discretion of the board.

50. Certificate of company commander as to qualification of candidates.—Each howitzer company commander submits to the board a list of the members of his command who are to appear for examination. He certifies on the list submitted by him that the candidates who have not previously qualified as second-class gunner or better are, as determined by a preliminary examination conducted under his supervision, well instructed in the care and use of matériel, drill of the gun squad, safety precautions to be observed during firing, and in the subjects of the examination.

51. Records and reports.—See AR 345–1000.

SECTION V

QUALIFICATION COURSE; GUNNER'S TEST

52. Scope.—This section prescribes the requirements of gunner's test "A," for use by the Regular Army, and of gunner's

test "B," for use of the National Guard during the armory training period only, when conditions are such as to prevent test "A" being conducted. It is divided into three subjects (par. 48*a*), as follows:

a. Subject No. 1.—Direct laying, 37-mm gun.

b. Subject No. 2.—Indirect laying, 37-mm gun.

c. Subject No. 3.—Laying the 3-inch trench mortar.

53. Scope of Subject No. 1.—Tests in Subject No. 1 include direct laying of the 37-mm gun, as follows:

a. Sighting triangles.

b. Laying on target.

c. Change in fire data.

d. Laying on aiming points.

54. Direct laying, 37-mm gun, sighting triangles.—*a.* Triangles will be made, using the telescopic sight, as prescribed in Chapter 1, Part One, Basic Field Manual, Volume III, with the following exceptions:

	Test A	Test B
Distance	100 yards	50 yards.
Number of triangles	4	2.
Diameter of disk	8 inches	4 inches.

b. All triangles made by a candidate will be on the same sheet of paper, which will be marked with his name.

c. Each triangle will be graded as follows:

	Test A	Test B	Score
No one side longer than	¾ inch	½ inch	5
No one side longer than	1 inch	¾ inch	3
No one side longer than	1¼ inches	1 inch	1
Total score possible	20 points	10 points	

55. Direct laying, 37-mm gun, on target.—*a.* Three X targets will be set up 25 yards from the gun. The distance between the targets for test "A" will be 15 yards, and for test "B," 5 yards.

b. Each candidate will have trials in laying on an aiming point as follows:

	Test A	Test B
With the telescopic sight	4	2
With the quadrant sight	4	2

c. With the candidate in a prone position behind the trails, the range and deflection dials on the sight set at zero and the gun in position on wheels, an officer gives a command for laying on one of the targets; for example:

RIGHT TARGET.
LEFT 10.
1,200.

d. The candidate repeats the order. At the announcement of the range he grasps the trails and points the barrel in the direction of the designated target, takes the position of gunner on the left trail, sets off deflection and range in compliance with the order, lays on the target, and calls, "Ready." Before the gun is laid an assistant seats the spades into the ground by jumping on the trails. The candidate is careful not to move his position any more than necessary when the laying is checked.

e. The same quadrant of the field of the telescopic sight will be used in each trial, and the crosslines of the quadrant placed tangent to the bull's-eye. When the quadrant sight is used, the intersection of the crosslines will cover the bull's eye.

f. Time is taken from the announcement of the range by the officer to the announcement of "Ready" by the candidate.

g. In each trial a different target, deflection, and range are ordered. No credit will be given in either of the following cases:

(1) If the sight is incorrectly set for deflection or range.

(2) If either crossline is more than 1 mil off its proper laying.

h. If the piece is found to be correctly laid within the limits prescribed, credits will be given as follows:

	Test A	Test B
Time in seconds exactly or less than	11–12–14–16–18	13–15–17–19–21
Credits	5 4 3 2 1	5 4 3 2 1
Total score possible	40 points.	20 points.

56. Direct laying, 37-mm gun, change in fire data.—*a.* Each candidate will have trials in applying changes in fire data to the sight and relaying on the aiming point as follows:

	Test A	Test B
With the telescopic sight	4	2

b. The candidate takes the position of gunner on the left trail with his hands on the elevating and traversing handwheels. With a given deflection and range set on the sight, and with the gun laid on an aiming point, an officer announces a deflection change and a range change not exceeding the limits prescribed in paragraph 49*f*. For example, the deflection being set at left 10, and the range at 1,000, and the gun laid on an aiming point an officer commands:

RIGHT 20.

800.

c. The candidate repeats the order, sets off the data ordered, relays on the aiming point and calls "Ready."

d. Time is taken from the announcement of the deflection by the officer to the announcement "Ready" by the candidate.

e. No credits will be given in the following cases:

(1) If the range or deflection dial is incorrectly set for the change announced.

(2) If either crossline is more than 1 mil off its proper laying on the aiming point.

f. If the piece is found to be correctly laid within the limits prescribed, credits will be given as follows:

	Test A	Test B
Time in seconds exactly or less than	7-8-9-11-13	7-8-9-11-13
Credits	5 4 3 2 1	5 4 3 2 1
Total score possible	20 points.	10 points.

57. **Direct laying, 37-mm gun, on aiming points.**—*a.* Three or more aiming points will be set out in such a manner that the angular distance in azimuth or elevation between any two is not less than 5 mils or greater than 20 mils. The aiming points will be capable of clear definition through the sights. White stakes about 4 inches wide and cut squarely at the top are preferable for test "A." Black pasters on a white background are more suitable for test "B."

b. Each candidate will have trials as follows:

	Test A	Test B
With the telescopic sight	4	2.
Distance, aiming points from gun	100 yards	50 yards.
Kind of aiming points	Stakes	Pasters.

c. The gun is placed firmly in position so that it will not be necessary to move the trail to lay upon either aiming point. With both range and deflection dials set at zero, the candidate in the gunner's position on the left trail, with his hands on the elevating and traversing handwheels, an officer commands, for example:

ZERO.
1,000.
LEFT TOP OF CENTER STAKE (OR CENTER PASTER).
SELECT AN AIMING POINT.

d. The candidate sets off the range as soon as it is announced and lays on the target designated in the command. He then moves the crosslines to the selected aiming point by means of the range and deflection dials and announces the new range setting. In succeeding trials the data in the commands will be varied. Time will be taken from the announcement of the range by the officer to the announcement of the new range setting by the candidate.

e. No credits will be given in the following cases:

(1) If the range and deflection found differ by more than 2 mils in deflection and 25 yards in range from the range and deflection determined by the board.

(2) If either crossline is more than 1 mil off its proper laying on the aiming point.

f. If the piece is found to be laid correctly within the prescribed limits, credits will be given as follows:

	Test A	Test B
Time in seconds exactly or less than	13-14-16-18-20	13-14-16-18-20
Credits	5 4 3 2 1	5 4 3 2 1
Total score possible	20 points.	10 points.

58. Maximum credits for direct laying, 37-mm gun.

	Test A	Test B
a. Total possible for sighting triangles	20	10
b. Total possible for laying on target	40	20
c. Total possible for change in fire data	20	10
d. Total possible for laying on aiming points	20	10
Total possible for direct laying, 37-mm gun	100	50

59. Scope of Subject No. 2.—Tests in Subject No. 2 include indirect laying of the 37-mm gun as follows:

a. With first fire data.

b. With change in fire data.

c. To measure minimum range.

d. By lensatic compass.

60. Indirect laying, 37-mm gun, with first fire data.—*a.* A well-defined vertical aiming point (such as a telegraph pole or a heavy line) will be used.

b. The candidate will have trials as follows:

	Test A	Test B
With the quadrant sight	4	2.
Distance AP from gun not less than	100 yards	50 yards.

c. With the candidate in the gunner's position on the left trail and with the piece so placed that it will not be necessary to move the trail to lay on the aiming point, an officer of the company commands, for example:

LEFT 15.
MINUS 10.
1,500.
TO YOUR FRONT, THAT TELEGRAPH POLE.

d. The candidate sets off the data as received; that is, deflection, angle of site, and range, and lays the vertical line of the collimator on the aiming point, and by turning the elevating screw handwheel centers the bubble.

e. As soon as the gun is laid the candidate calls, "Ready."

f. Time will be taken from the announcement of the deflection by the officer to the announcement "Ready" by the candidate.

g. No credits will be given in the following cases:

(1) If the sight is incorrectly set for deflection, site, or range.

(2) If the level bubble is not more than half inside the two lines on the glass tube.

(3) If the vertical line is more than 1 mil off the aiming point.

h. If the piece is found to be correctly laid within the limits prescribed, credits will be given as follows:

	Test A	Test B
Time in seconds exactly or less than	13-14-16-18-19	15-16-18-20-22
Credits	5 4 3 2 1	5 4 3 2 1
Total score possible	20 points.	10 points.

61. Indirect laying, 37-mm gun, change in fire data.—*a.* The candidate will have trials as follows:

	Test A	Test B
With the quadrant sight	4	2

b. With a given deflection, angle of site, and range set on the sight, the vertical line of the collimator laid on an aiming point and the bubble centered, an officer of the company announces a range and deflection change not to exceed the limits prescribed in paragraph 49*f*. For example, with the range set at 1,000, deflection at left 10, an officer of the company commands:

RIGHT 20.

800.

c. The candidate sets off the data ordered, relays the vertical line on the aiming point, centers bubble, and calls, "Ready."

d. Time will be taken from the announcement of the deflection by the officer to the candidate's announcement, "Ready."

e. No credit will be given in the following cases:

(1) If the sight is incorrectly set for deflection, angle of site, or range.

(2) If the level bubble is not more than half inside the two lines on the glass tube.

(3) If the vertical line is more than 1 mil off the aiming point.

f. If the piece is found to be correctly laid within the limits prescribed, credits will be given as follows:

	Test A	Test B
Time in seconds exactly or less than	10–11–13–15–16	11–13–15–17–19
Credits	5 4 3 2 1	5 4 3 2 1
Total score possible	20 points.	10 points.

62. Indirect laying, 37-mm gun, to measure minimum range.—*a.* The candidate will have trials in measuring the minimum range over a mask as follows:

	Test A	Test B
With the quadrant sight	3	2

b. Different ranges to mask and angles of site will be assumed for each trial.

c. With the gun in position pointed toward mask and with range and deflection dials set at zero, an officer of the company commands, for example:

RANGE TO MASK, 400.

ANGLE OF SITE, MINUS 10.

d. The candidate sets off the data as received and announces the minimum range.

e. Time will be taken from the announcement of the range to the mask by the officer to the announcement of the minimum range by the candidate.

f. No credits will be given in the following cases:

(1) If the angle of site is incorrectly set.

(2) If the minimum range announced differs by more than 50 yards from the minimum range determined by the board.

g. If the minimum range is found to be correct within the limits prescribed, credits will be given as follows:

	Test A	Test B
Time in seconds exactly or less than	12–14–16–17–18	14–15–17–19–20
Credits	10 8 6 4 2	10 8 6 4 2
Total score possible	30 points.	20 points.

63. Indirect laying, 37-mm gun, by compass.—*a.* The candidate will have trials, using the compass, in laying the piece on a given magnetic azimuth, as follows:

	Test A	Test B
Number of trials	3	1

b. The selected firing position is marked by a low flat topped stake or some small object.

c. The gun, with quadrant sight attached, is set up as in ***On wheels, action*** (Basic Field Manual, Volume II), 15 yards from the selected firing position, but not necessarily pointed in the direction of fire and an officer of the company commands, for example:

MAGNETIC AZIMUTH, 2,200.

d. The candidate estimates the approximate direction of the azimuth ordered and directs an assistant to move out about 25 yards in that direction. The candidate then, by employing the compass, directs the assistant to drive a stake in such a position that it will have the required azimuth from the gun, places the gun in such a position that the sight is approximately over the stake or other object indicating the gun position, lays the vertical line of the collimator on the aiming stake and calls, "Ready."

e. Time will be taken from the announcement of the magnetic azimuth by the officer to the candidate's "Ready." The board checks the direction of the aiming stake from the gun by reading the azimuth from the aiming stake to the stake at the firing position, and converting it to back azimuth. No credit will be given if the piece is laid more than 40 mils off the magnetic azimuth commanded. Credits will be given as follows:

	Test A	Test B
Time in seconds exactly or less than	90–105–120–135–150–180	90–105–120–135–150–180
Credits—error of 0–20 mils	10 9 8 7 6 5	10 9 8 7 6 5
Credits—error of 21–40 mils	8 7 6 5 4 3	8 7 6 5 4 3
Total score possible	30 points.	10 points.

64. Maximum credits for indirect laying, 37-mm gun.

	Test A	Test B
a. Total possible for first fire data	20	10
b. Total possible for change in fire data	20	10
c. Total possible for measuring minimum range	30	20
d. Total possible for laying by compass	30	10
Total possible for indirect laying, 37-mm gun	100	50

65. Scope of Subject No. 3.—Tests in Subject No. 3, laying 3-inch trench mortar, include—

a. Digging base-plate pit.

b. Laying for elevation and direction.

c. Establishing the line of direction with alidade or lensatic compass, mortar position fixed.

d. Establishing the line of direction with aiming stakes, alidade, or lensatic compass, mortar position not fixed.

66. Laying 3-inch trench mortar; digging base-plate pit—*a. Equipment required*—(1) *For the candidate.*—Base plate, barrel mount, clinometer, short-handled shovel, and two sandbags.

(2) *For the board.*—Ruler, straightedge at least 4 feet long, protractor, stop watch, and score card.

b. Conditions.—(1) The candidate will be allowed to choose one assistant, whose sole duties during the test will be to hold the sandbags while the candidate is filling them, to assist the candidate in placing the sandbags in the pit, and in settling the base plate in the pit.

(2) The board announces to the candidate the approximate position of the base-plate pit, the target, which will be a stake between 500 and 600 yards from the gun position and clearly visible from it, and the angle at which the base plate is to be set in the pit; that is, 40°.

(3) The candidate is allowed to arrange his equipment in any way he desires.

(4) The candidate is allowed to settle the base plate in the pit by striking the base plate with the rear end of the barrel.

(5) In checking the angle of the base plate with the horizontal, the board uses the same clinometer which was used by the candidate.

(6) If any obstacles, such as large rocks, are encountered beneath the surface of the ground, making it impossible for the

gunner to complete the digging of the pit, the candidate will be given another trial.

c. Procedure in base-plate pit digging test.—(1) At the command ***Time,*** given by a member of the board, the candidate aligns the base plate on the target, digs the base-plate pit, and inserts the sandbags and base plate in the pit in the manner described in paragraph 17 and in Basic Field Manual, Volume II.

(2) At the completion of this task the candidate calls, "Ready."

(3) The board then checks the work of the candidate. The deflection is checked as follows:

(*a*) Lay the diameter line of the protractor along the upper edge of the base plate so that the index of the protractor is at the center of the upper edge of the base plate and the protractor is approximately horizontal.

(*b*) Align the straightedge on the target, with one end of the straightedge in coincidence with the index of the protractor.

(*c*) Take a reading where the straightedge crosses the scale of the protractor. The difference between this reading and 1,600 mils is the error in deflection.

d. Scoring in base-plate pit digging test.—(1) No credits will be given in the following cases:

(*a*) If the top of the base plate is above the ground.

(*b*) If the slope of the base plate is more than 3° greater or less than 40°.

(*c*) If the top edge of the base plate makes with the line mortar target an angle greater than 1,680 mils or less than 1,520 mils; that is, if the error in deflection is greater than 80 mils.

(*d*) If the sandbag on the forward slope of the pit has not been placed in the pit so that the bottom edge of the sandbag is resting upon the rear slope.

(*e*) If the base-plate pit is more than 1 inch longer than the base plate.

(*f*) If the time exceeds 10 minutes.

(2) If the pit is found to be correct within the above limits, the following credits will be given:

	Test A			Test B	
Slope of base plate greater or less than 40° by exactly or less than	1°	2°	3°		3°
Credits	15	10	5		5
Angle of top of base plate with line mortar-target greater or less than 1,600 mils by exactly or less than	20M	40M	60M	80M	80M
Credits	20	15	10	5	5
Total score possible (sum of above)			35		10

67. Laying 3-inch trench mortar for elevation and direction—*a. Equipment required*—(1) *For the candidate.*—Base plate, barrel, mount, two filled sandbags, one aiming stake, clinometer, and fire-control tables.

(2) *For the board.*—Stop watch, plumb bob, two aiming stakes, and score card.

b. Conditions.—(1) The mortar will be set up on the base-plate pit with the traversing and elevating mechanism centered. Two filled sandbags will be at the mortar position.

(2) The line mortar-target will be defined by two stakes driven 15 yards apart, with the nearer stake at 50 yards in front of the mortar in such position that the legs of the mortar will not have to be moved more than 1 foot in laying the mortar on the stake.

(3) The candidate is allowed to choose one assistant whose sole duties will be the duties in laying the piece as prescribed for Nos. 1 and 2 in Basic Field Manual, Volume II.

(4) The test of laying the mortar with initial fire data will be given first.

(5) In checking elevation the board will use the same clinometer as used by the candidate.

c. Procedure in laying 3-inch trench mortar, with first fire data.—(1) The candidate will have trials as follows:

	Test A	Test B
Number of trials	2	1

(2) The candidate takes position at the post of the gunner, equipped with fire-control tables and clinometer.

(3) A member of the board then gives the candidate a verbal order, as:

550.
THOSE STAKES.
ONE ROUND.

(4) The candidate repeats the order, consults his range table, announces the number of rings to be used, causes the sandbags to be placed on the legs, lays the mortar at the proper direction and elevation, and gives the command: ***FIRE.***

(5) The board checks the elevation and then the direction, the direction being checked as follows:

(*a*) Stakes are driven 2 feet to the right and left of the aiming stake, nearer the mortar, on which the mortar was aligned by the candidate. These stakes are driven so that their outer edges are exactly 4 feet apart.

(*b*) A plumb bob is suspended over the center of the base cap. A member of the board sights along the line established by the string of the plumb bob and the top of the white aiming line on the mortar and determines whether the mortar is laid within the limits established by the outer edges of the two stakes driven by the board.

d. Scoring of test for laying with first fire data.—(1) Time will be taken from the announcement of the range in the fire order given by the officer conducting the test.

(2) No credit will be given the candidate for any trial not completed within a time limit of two minutes.

(3) For each trial found to be completed within the prescribed time limit the candidate will be given credits as follows:

	Test A	Test B
For laying in direction within the prescribed limits (2 feet on either side of the nearer aiming stake)	6	6
For announcing the proper number of rings to be used	1	1
For error in elevation of exactly or less than 1°	3	3
For error in elevation of exactly or less than 2°	2	2
For error in elevation of exactly or less than 3°	1	1
For error of over 3°	0	0
Possible credits	20	10

e. Procedure in laying 3-inch trench mortar, change in fire data.—(1) In this test the candidate will have trials as follows:

	Test A	Test B
Number of trials	3	2

(2) The candidate takes position at the post of the gunner, equipped with fire-control tables and clinometer.

(3) One member of the board takes post 50 yards to the front of the mortar. From that position he signals changes in direction and range, as:

RIGHT TWO TURNS.
DOWN 100.
ONE ROUND.

Such changes will not be so great as to necessitate shifting the legs of the mortar.

(4) The candidate repeats the signals, consults his range table, announces the number of rings to be used, relays the mortar according to the data signaled and commands: ***FIRE.***

(5) The board notes carefully the actions of the candidate in applying the new firing data to the mortar and then checks the elevation with the clinometer.

f. Scoring of test for laying, change in fire data.—(1) Time will be taken from the last movement of the candidate's arm in repeating the signaled order.

(2) No credit will be given the candidate for any trial not completed within a time limit of 45 seconds.

(3) For each trial found to be completed within the prescribed time limit, the candidate will be given credits as follows:

	Test A	Test B
For correctly applying the given change of deflection to the mortar	1	1
For announcing the proper number of rings to be used	1	1
For error in elevation of exactly or less than 1°	3	3
For error in elevation of exactly or less than 2°	2	2
For error in elevation of exactly or less than 3°	1	1
For error of over 3°	0	0
Possible credits	15	10
Total possible credits for laying the mortar	35	20

68. Establishing the line of direction with alidade or compass, mortar position fixed—*a. Equipment*—(1) *For the candidate.*—Mortar, 2 aiming stakes, 2 hand axes, 1 alidade, and 1 compass.

(2) *For the board.*—Drawing board, protractor, and score cards.

b. Conditions.—(1) The mortar will be mounted in a position selected by the board, muzzle pointing in the general direction of the target.

(2) The target will be a well-defined, vertical line, visible from the mortar, set out as follows:

	Test A	Test B
Distance, mortar to target between	500 and 700 yards	50 and 70 yards.

(3) The candidate chooses either the alidade or compass method and announces his choice to the board.

c. Procedure in test, mortar position fixed.—(1) The board conducts the candidate to a point in front of the mortar and off the line mortar-target, as designated below, and points out the mortar and the target.

	Test A	Test B
	Yards	*Yards*
Distance in front of mortar	50	25
Distance from line mortar-target (approximate)	25	10

(2) At the command ***Time,*** given by the board, the candidate establishes a stake on the line mortar-target, 50 yards from the mortar (25 yards in case gunner's test "B" is being given) using either the alidade or compass method.

(3) At the completion of this task the candidate calls, "Ready."

(4) The board then proceeds to the mortar position and by means of the drawing board and protractor determines the accuracy of the line established by the mortar and stake. In checking for accuracy, the board sights along either edge (or top) of the stake, as the candidate may choose, but the candidate announces this choice to the board before he arrives at the mortar position.

d. Scoring in test, mortar position fixed.—(1) No credit will be given in the following cases:

(*a*) If the time exceeds five minutes.

(*b*) If the line established by the stake diverges from the line mortar-target by more than 40 mils.

(2) If the task is found to be correct within the limits prescribed, credits will be given as follows:

	Test A			Test B		
Error in mils exactly or less than	10	20	40	10	20	40
Credits:						
Time less than 3 minutes	15	12	10	10	8	6
Time between 3 and 4 minutes	13	10	8	8	6	4
Time between 4 and 5 minutes	10	8	6	6	4	2
Total possible points			15			10

69. Establishing the line of direction with aiming stakes, alidade, or compass, mortar position not fixed—*a. Equipment.*—Same as in paragraph 68 *a*, except that one additional stake is required.

b. Conditions.—(1) The board designates to the candidate the general location in which the mortar is to be mounted.

(2) The target will be a well-defined line clearly visible from the approximate mortar position set out as follows:

	Test A	Test B
Distance, mortar position to target between.	500 and 700 yards	50 and 70 yards.

(3) An assistant is allowed the candidate in this test.

(4) The candidate chooses either the stake or compass method and announces his choice to the board.

c. Procedure in test, mortar position not fixed.—(1) The board conducts the candidate to a point in front of the approximate position, as designated below, and points out the target.

	Test A	Test B
	Yards	*Yards*
Distance in front of approximate mortar position	50	25

(2) At the command ***Time,*** given by the board, the candidate, using the stake, alidade, or compass method, sets out two stakes to determine the line of direction. The placing of these stakes will be governed by the following conditions:

	Test A	Test B
	Yards	*Yards*
Distance between stakes not less than	25	15
No stake closer to the mortar than	25	15
Distance of 1 stake from mortar position	25	15

(3) The candidate then sets out a stake or directs the setting out of a stake to indicate the exact position of the mortar.

(4) At the completion of this task the candidate calls, "Ready."

(5) The board then tests the accuracy of the line of direction in the same way as in the preceding test. (Par. 68*c*.)

d. Scoring in stakes test, mortar position not fixed.—(1) No credits will be given in the following cases:

(*a*) If the time exceeds four minutes.

(*b*) If the line established by the stakes diverges from the line mortar target by more than 40 mils.

(2) If the task is found to be correct within the limits prescribed, credits are given as follows:

	Test A			Test B		
Error in mils exactly or less than	10	20	40	10	20	40
Credits:						
Time less than 2 minutes	15	12	10	10	8	6
Time between 2 and 3 minutes	13	10	8	8	6	4
Time between 3 and 4 minutes	10	8	6	6	4	2
Total possible points			15			10

70. Maximum credits for laying 3-inch trench mortar.

	Test A	Test B
a. Digging base-plate pit	35	10
b. Laying for elevation and direction	35	20
c. Establishing the line of direction, mortar position fixed	15	10
d. Establishing the line of direction, mortar position not fixed	15	10
Total possible for laying 3-inch trench mortar	100	50

SECTION VI

QUALIFICATION COURSE; EXPERT TEST

71. Scope.—This test is divided into four subjects (par. 48*b*), as follows:

a. Subject No. 1.—Preparation of range cards.

b. Subject No. 2.—Computation of firing data for 37-mm gun.

c. Subject No. 3.—Individual field firing, 37-mm gun.

d. Subject No. 4.—Individual field firing, 3-inch trench mortar.

72. Range cards.—*a.* This test includes the preparation of a range card as prescribed in paragraph 82 for a defensive position.

b. The position and sector will be selected by the examining board. The sector will include a reference point and four target positions, each of which will be definitely located by some distinctive feature of the terrain and pointed out on the ground to the candidate. The target positions will be between 500 and 1,500 yards from the selected gun position and at least 100 mils in azimuth from the reference point.

c. The same position and sector will be used for all candidates examined on any one day, and, if practicable, all candidates serving at the same post will be examined on this subject on the same day.

d. The candidate is furnished a lensatic compass.

e. Ranges are estimated.

f. All range cards will be made out on blank paper furnished by the examining board.

g. No credit will be allowed for any range card not submitted within 30 minutes.

h. Correct ranges, angles of site, and azimuth angles will be determined by the examining board, and each target as shown on the candidate's range card will be graded for accuracy as follows:

(1) Percentage of error in range exactly or less than	15	20	25	30	35
Credits	10	8	6	4	2
Total possible for range estimation (4 targets and reference point)	50				
(2) Error in azimuth angle exactly or less than (mils)	10	15	20	25	
Credits	4	3	2	1	
Total possible for azimuth measurements (4 targets and reference point)	20				
(3) Error in angle of site exactly or less than (mils)	5	10			
Credits	2.5	1			
Total possible for angle of site estimation (4 targets)	10				

(4) For the recording, proper placing, and legibility of each of the following on the range card:

	Credits
Base line and range arcs	0.5
Calibration of range arcs	.5
Diagrammatic sketch of each target and RP	2.5
Nominal designation of each target and RP	2.5
Numerical designation of each target	2.0
Accentuation of zero line	.5
Range to RP and to each target	2.5
Magnetic azimuth of RP and of each target	2.5
Angle of site of each target	2.0
Arrow and letter indicating magnetic north	1.0
Type and number of emplacement	1.0
Name, grade, and organization of candidate	1.5
Place and date	1.0
Total possible (for completeness, correct technique, and legibility)	20.0

i. Total possible for range cards, 100.

73. **Computation of firing data for the 37-mm gun.**—*a.* A well-defined target, visible from both the observation post and the gun position, will be set out or selected by the examining board. The target will be between 500 and 1,500 yards from the gun position. The observation post will be between 100 and 200 yards from the gun position and at least 100 yards to one flank of the line gun-target. The target and gun position will be designated to the candidate from the observation post, and he will not be allowed to move from this position while computing the required data.

b. The candidate is furnished a compass and field glass, type EE. No other instrument will be used.

c. The candidate will determine the magnetic azimuth, angle of site, and range from gun to target.

d. The correct data will be determined by the examining board, using the same compass as the candidate.

e. No credits will be allowed for any data not submitted within five minutes.

f. Firing data submitted within the prescribed limit will be graded as follows:

(1) Magnetic azimuth gun target—						
Error in mils, exactly or less than	20	40	60	80	100	120
Credits	35	30	25	20	15	10
(2) Angle of site gun target—						
Error in mils, exactly or less than	--	--	--	5	10	15
Credits	--	--	--	30	15	5
(3) Range gun target—						
Percentage of error, exactly or less than	10	15	20	25	30	35
Credits	35	30	25	20	15	10

Possible for computation of firing data for the 37-mm gun (Subject No. 2), 100.

74. Individual field firing, 37-mm gun—*a. Regulations.*—Each candidate will conduct the firing of one problem in direct laying, using aiming point other than the target, and one problem in indirect laying.

b. Grading.—The conduct of each problem of the candidate is graded upon the following basis:

Accuracy of original fire order	15
Accuracy of observation of errors	15
Conduct of fire, issuing and transmitting fire orders, method of adjusting fire, decision, and promptness	20
Total for 1 problem	50

Total credits possible for one problem in firing with direct laying and one problem in firing with indirect laying, 100.

c. Procedure.—Individual field firing with the 37-mm gun will be conducted under the following conditions:

(1) Only those who have made 95 per cent of the total possible 200 points in Subjects 1 and 2 of the expert test will fire. (Par. 48*b*.)

(2) For each problem—

(*a*) The target will be clearly designated to the candidate.

(*b*) The candidate computes the firing data and gives the gunner the necessary order to enable him to lay the piece and open fire upon the target.

(*c*) After firing has commenced, the candidate observes all bursts and makes the proper corrections until fire is adjusted upon the target.

(*d*) The actual range to target will not be less than 500 yards nor greater than 1,500 yards.

(*e*) The authorized ammunition allowances will not be exceeded.

(3) The board will terminate a problem when it is considered that the conduct of fire is inefficient or that fire has been adjusted on the target. No fire for effect will be ordered.

(4) In the direct laying problem the telescopic sight is used. A clearly defined aiming point is employed. The candidate will be required to measure by means of his field glass the angle in azimuth and the angle in elevation between the target and the aiming point and compute the necessary firing data from these measurements.

(5) In the indirect laying problem the gun is in such a position that no part of the gun or crew is visible from the target, but the candidate by standing upright at or near the gun position can see the target. The quadrant sight will be used.

(6) If practicable, all members of the platoon except those who are yet to take the firing test will be permitted to witness the firing.

(7) No person will correct or coach the candidate at any time during firing, and no one except an official conducting the examination will communicate or in any way interfere with any person connected with the firing.

75. Individual field firing, 3-inch trench mortar.—*a.* Each candidate conducts the firing of one problem in indirect laying.

b. Only those who have made 95 per cent of the total possible 300 points in Subjects 1, 2, and 3 of the expert test will fire. (Par. 48*b*.)

c. The conduct of each problem by the candidate is graded upon the following basis:

Accuracy of original fire data	30
Accuracy of observation of errors	30
Conduct of fire, issuing and transmitting fire orders, method of adjusting fire, decision, and promptness	40
Total for the problem (Subject No. 4)	100

d. Individual field firing with the 3-inch trench mortar is conducted under the following conditions:

(1) The target will be clearly designated to the candidate and will not be visible from the mortar position.

(2) The candidate is permitted to select a gun squad, and directs the digging of the base-plate pit, inspection, and setting up of the mortar.

(3) The observation post will not be closer than 100 yards to nor farther than 200 yards from the mortar position and will be within 20 yards of the line mortar-target.

(4) The candidate computes the firing data and gives the gunner the necessary commands to enable him to lay the mortar and open fire on the target.

(5) After firing has commenced, the candidate observes all bursts and makes the proper corrections until fire is adjusted on the target.

(6) All firing will be with practice or dummy ammunition which has been loaded to the same weight as live ammunition with fuzes.

(7) The actual range to the target will not be less than 350 yards nor greater than 750 yards.

(8) The board will terminate a problem when it is considered that the conduct of fire is inefficient or that fire has been adjusted on the target.

(9) No person will correct or coach the candidate at any time during firing, and no one except an official conducting the examination will communicate or in any way interfere with any person connected with the firing.

(10) The authorized ammunition allowances will not be exceeded.

76. Maximum credits for expert test.

a. Subject No. 1.—Range cards	100
b. Subject No. 2.—Computation of firing data for 37-mm gun	100
c. Subject No. 3.—Individual field firing, 37-mm gun: Direct-laying problem, 50; indirect-laying problem, 50	100
d. Subject No. 4.—Individual field firing, 3-inch trench mortar	100
Total possible for expert test	400

CHAPTER 3

TECHNIQUE OF FIRE OF THE 37-MM GUN AND THE 3-INCH TRENCH MORTAR

		Paragraphs
SECTION I.	37-mm gun	77–82
II.	3-inch trench mortar	83–89

SECTION I

37-MM GUN

77. Direct laying—*a. General.*—(1) Direct laying is the technique required to engage a target that can be seen by the gunner from his position on the trail.

(2) When the target is distinctly visible and offers a well-defined aiming point, the gunner may lay directly on that part of it which he desires to hit. This method offers the advantage of reducing to a minimum the time preliminary to the first round. It has the disadvantage that in fire for effect the target may be obscured by bursting shells, thus causing the gunner to lose sight of his aiming point.

(3) When the target can not be easily designated to the gunner, or offers a poor aiming point, or is likely to be obscured by smoke or dirt from bursting shells, an aiming point other than the target is ordinarily used.

(4) The telescopic sight (Chapter 2, Part Two, Basic Field Manual, Volume III) is designed for direct laying. The required direction and elevation are applied to the gun by setting the deflection and range dials at the deflection and range announced in the fire order, then manipulating the traversing and elevating mechanism until the crosslines are laid on the aiming point. The aiming point should appear within one of the quadrants formed by the intersecting crosslines, touching the line segments as shown in Figure 14. In laying for succeeding rounds

fired on the same target the same quadrant should be used. The part of the object most clearly defined should be used as the aiming point. The eye should be placed firmly against the eye shield so that no light enters. When the field of vision is a true circle, the eye is in the proper position.

b. Using the target as the aiming point.—To lay the gun when the target is the aiming point—

(1) Set the deflection dial at the announced deflection, usually zero.

(2) Set the range dial at the range to the target, as given in the fire order.

(3) By means of the elevating and traversing handwheels of the gun, lay the intersection of the crosslines upon that part of the target selected for an aiming point.

c. Using an aiming point other than the target—(1) *Mechanical method.*—This method is used when the target does not offer

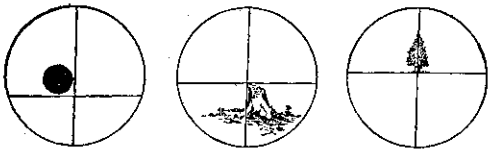


FIGURE 14.—Alignment of sight and aiming point

a good aiming point or when it is likely to be obscured by smoke or dirt resulting from the bursting of shells, especially during fire for effect. The mechanical part of the work is performed by the gunner, either upon instructions from the gun commander or upon his own initiative if he finds the target is a poor aiming point. The gunner must announce to the gun commander the final setting on the range dial of the sight, as this setting is the result of his action and must be known by the gun commander when adjusting fire. To compute the firing data by the mechanical method proceed as follows:

(*a*) Set the deflection and range dials in compliance with the data given in the fire order.

(*b*) Lay the gun, using the target as an aiming point, by manipulating the traversing and elevating mechanism.

(*c*) Without disturbing the laying of the gun, turn the deflection and range dials of the sight until the crosslines are laid on the selected aiming point.

(*d*) Announce the new reading on the range dial to the gun commander. The gun is relaid for each round after the first by applying corrections, as given in adjustment orders, on the sight and relaying on the same aiming point. It is necessary for the gun commander to know the new range setting, introduced by moving the crosslines of the sight to the new aiming point, in order that he may give correct fire orders.

Range table for 37-mm. gun, HE shell Mk. II, muzzle velocity 1,276 f/s

(Extract of 37-A1)

Range	Elevation	Range	Elevation	Range	Elevation
Yards	*Mils*	*Yards*	*Mils*	*Yards*	*Mils*
0	−5	700	23	1,400	60
100	−2	800	28	1,500	66
200	+2	900	33	1,600	73
300	6	1,000	38	1,700	79
400	10	1,100	43	1,800	86
500	14	1,200	49	1,900	93
600	19	1,300	54	2,000	100

(2) *Mil-scale and range-table method.*—In many cases the target is obscure and difficult to designate. The observer can see the target with his field glasses, which have a greater magnifying power than the sight used by the gunner. Therefore, he can select an aiming point other than the target, and by calculation determine the firing data which will enable the gunner to lay on the selected aiming point and give the gun the necessary direction and elevation to engage the target. To compute the firing data by means of the mil-scale and range-table method, proceed in the manner described below. From a position at or near the gun—

(*a*) Estimate the range to the target.

(*b*) By means of the mil-scale in the field glasses, measure the horizontal angle in mils from the aiming point to the target.

(*c*) By means of the mil-scale in the field glasses, measure the vertical angle in mils between the aiming point and target.

(*d*) Refer to the range table (37–A1) and determine the angle of elevation which corresponds to the estimated range to the target. Increase or decrease this angle of elevation, depending on whether the aiming point is below or above the target, by the measured vertical angle, aiming point to target.

(*e*) Find in the range table the range equivalent to the new angle of elevation, obtained by the above computation. This is the range to be used for the first round.

(*f*) The deflection to be set off on the sight is the horizontal angle in mils, as read from aiming point to target.

Discussion: Setting off right (left) deflection on the deflection dial of the sight will cause the projectile, under normal conditions, to strike to the right (left) of the aiming point on which the gun is laid. Therefore, if the horizontal angle read from aiming point to target is right 20 mils, and a deflection setting of right 20 is set on the sight, and the crosslines of the sight laid on the aiming point by manipulating the traversing mechanism, the barrel will be given proper direction for opening fire on the target. If the range to a target is set off on the range dial and the gun laid on the target by manipulating the elevating mechanism until the intersection of the crosslines of the sight is on the target, the barrel is given the proper elevation above the line of aim to cause the projectile to strike the target. If the aiming point to be used is *above* the target a certain number of mils, this vertical angle in mils must be *deducted* from the angle of elevation required on the gun for the projectile to strike the target, if the target itself were used as an aiming point. If the aiming point to be used is *below* the target, the vertical angle in mils, aiming point to target, must be *added* to the angle of elevation required on the gun in order for the projectile to strike the target, if the target itself were used as an aiming point.

Example.—The gun commander wishes to calculate firing data for opening fire on a target estimated to be 1,200 yards from the gun. By using his field glasses he measures the horizontal angle, aiming point to target to be right 15 mils, and the vertical angle from aiming point to target to be 20 mils. The aiming point is above the target. Referring to the fire-control tables he sees that the angle of elevation for 1,200 yards is 49 mils. 49 minus 20 equals 29 (aiming point above target). Again referring to the fire-control tables he sees that an angle of elevation of 29 mils is equivalent to a range of 820 yards. The data used in his fire order then should be deflection right 15; range 800, using the nearest range in hundreds.

(3) *The 5-mil method.*—The 5-mil method of calculating data for using an aiming point other than the target is based on the mil-scale and range-table method. It is a rapid method and sufficiently accurate for practical field work. It will be seen from the fire-control tables that, for average combat ranges of the 37-mm gun, the angles of elevation differ by approximately 5 mils, for ranges differing by 100 yards. Recognizing this fact, the observer can obtain the range to be used for an aiming point above or below the target without reference to a table, by making a correction of 100 yards in range setting for each 5 mils which the aiming point is above or below the target.

Example.—The gun commander wishes to calculate firing data to open fire on a target 1,000 yards from the gun. He wishes to use an aiming point which is to the right of and *below* the target. By using his field glasses he reads the horizontal angle aiming point to target to be left 25 mils and the vertical angle aiming point to target to be 15 mils. Based on the fact that a change of 5 mils in elevation is equivalent to a change of 100 yards in elevation, he corrects the range to the target by 300 yards ($\frac{15}{5}\times100=300$). The data given in his fire order will then be deflection left 25 mils and range 1,300 yards. The correction is added since the aiming point is below the target.

78. Indirect laying—*a. General.*—(1) Indirect laying is the technique required in order to engage a target that can not be seen by the gunner from his position on the trail. The three problems involved in this type of fire are direction, elevation, and minimum range. In order to engage a given target it is necessary, first, to establish the direction of the line gun-target; then to determine the angle through which it is necessary to elevate the barrel from the horizontal, in order for the projectile to strike the target, and finally, to determine the minimum range; that is, the least range setting which will insure the projectile clearing the mask to the front, while engaging the target from one position.

(2) The quadrant sight (Chapter 2, Part Two, Basic Field Manual, Volume III) is designed for direct laying. The required direction (with exception of the position defilade method) and elevation are applied to the gun by setting the deflection dial, angle-of-site dial, and range dial in accordance with the data

given in the fire order, then laying the vertical line of the collimator on the aiming point by means of the traversing mechanism and finally centering the bubble in the level vial by means of the elevating mechanism.

b. Procedure.—When the observer sees the target he immediately determines the range and angle of site, and, except in the case of position defilade, selects or establishes a suitable aiming point. The general sequence of procedure for the application of indirect laying, after the target has been located and recognized, is as follows:

(1) Establishment of direction of the target (assisted by No. 3, if necessary).

(2) Mounting the gun for action on wheels or tripod.

(3) Announcement by the observer to the gunner of the angle of site of the target.

(4) Determination of the minimum range, by the gunner, and his announcement of the same to the observer.

(5) Announcement, by the observer to the gunner, of the fire order, and the gunner's repetition of the same.

(6) Fire adjustment and fire for effect to execute the given mission.

(7) Changing position, or going out of action.

c. Establishing direction.—Several alternative methods for establishing direction are hereinafter described. Each method is practical, and sufficiently accurate for opening fire on a given target. Different conditions demand the use of different methods. The one to be used in any particular situation is left to the discretion of the observer who is usually the gun commander. The methods described for use from position defilade, and for the use of a natural aiming point are almost as rapid as direct laying and permit of added protection for the gun crew due to an intervening mask.

(1) *From position defilade.*—The gun is said to be in position defilade when it is so located just behind a crest that the gun and men lying on the trails are obscured from the enemy's view, but the observer, standing at the gun, is able to see the target. A gun in such a position is laid by the following procedure: The observer grasps the trails and moves them until the barrel is pointed in the direction of the target. The gunner takes position and turns the deflection dial until the vertical line of the collimator is aligned on some clearly defined object which can be used as an aiming point. This aiming point may

be a stone or other object in the immediate foreground, or an object on the sky line. If no suitable object is visible, something may be thrown on the ground in front of the gun within the field of view of the sight (such as a sight case, ammunition box, or stone) or a stake may be driven.

(2) *By use of an aiming point.*—From a position in front of, or in rear of the gun position, the observer selects an aiming point, preferably within a horizontal angle of 50 mils of the target to facilitate lateral adjustment, since the deflection dial is graduated to 70 mils in each direction. The aiming point may be at a range greater or less than the range of the target. The observer must be able to see both aiming point and target. The gunner sees only the aiming point due to an intervening mask. The deflection dial is set at the deflection as read from aiming point to target and the vertical line of the collimator aligned on the aiming point by manipulating the traversing mechanism. If the observer is near the gun position the deflection read, aiming point to target, is the deflection to be applied on the sight. If the observer is in front (rear) of the gun position the deflection read will be greater (less) than the deflection to be applied on the sight. This correction factor varies as the ratio $\frac{\text{Distance observer-target}}{\text{Distance gun-target}}$. For example, if the observer is 200 yards in front of the gun, the range gun target is 800 yards, and the deflection read by the observer is 40 mils, the deflection to be applied on the gun is $\frac{600}{800}\times 40=30$ mils. However, it is seldom necessary to make any except very approximate corrections, since the observer is usually relatively near the gun, and, unless the correction is computed very rapidly, time is saved by opening fire and adjusting fire for direction.

(3) *By compass and mil formula.*—This method is applicable where the observer is off the line gun-target. The procedure is as follows:

(*a*) The observer reads the azimuth of the line observer-target.

(*b*) He then estimates the distance observer-target and the shortest distance from his position to the line gun-target.

(*c*) He divides the latter distance by $\frac{1}{1000}$ of the distance observer-target.

(*d*) He then corrects the azimuth read from his position by adding or subtracting the quotient of the above division. This will give the azimuth on which the gun should be laid. If the

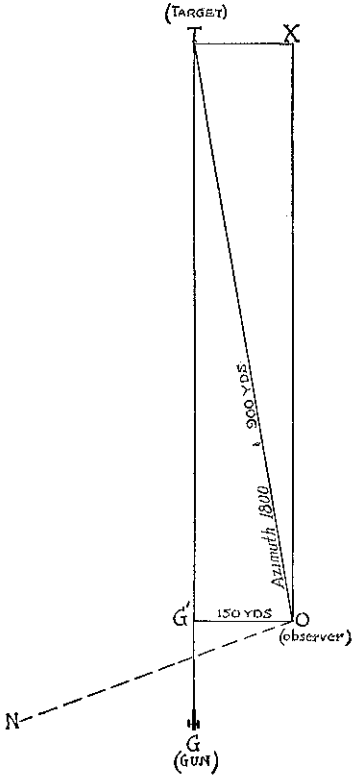


FIGURE 15.—Compass and mil formula method

gun is on the left of the observer he adds the quotient to the azimuth observer-target, if the gun is on his right he subtracts.

Example: Azimuth *O–T*=1,800 m.
Distance *O–T*=900 yards.
Distance *O*–line *G–T*=150 yards.

$$\frac{150}{.9}=166$$

Correcting the azimuth of 1,800 mils by adding (gun on left) the 166 mils will give the azimuth gun-target 1,800+166=1,966.

Discussion.—The observer *O* reads the azimuth *O–T* to be 1,800 mils, estimates the range *OT* to be 900 yards and the distance *O–G'* to be 150 yards. The azimuth *G–T* will be identical to the azimuth *O–X* (*O–X* constructed parallel to *G–T*). The correction necessary to be applied to azimuth *O–T* is equivalent to the angle *TOX*. The value of angle *TOX* is unknown. But angle *G'TO* equals angle *TOX*. (Alternate interior angles formed by a transversal cutting parallel lines are equal.) The value of angle *G'TO* can be determined by the mil formula $M=\frac{1000}{R}W$. This formula is simplified for rapid practical use by dividing both numerator and denominator of the fraction by 1,000. Then $M=\frac{W.}{R.}$ In this case *W* equals *G'O*, and *R* equals *OT*. From Figure 15 the azimuth of line *OX* is greater than the azimuth of line *OT*. But since the lines *OX* and *GT* are parallel, the azimuth of line *OX* is the same as the azimuth of line *GT*, the desired azimuth. Therefore the correction must be added. A convenient method for teaching observers to know quickly whether the correction should be added or subtracted is to use the word "LARS" (Left add, right subtract); that is, if the gun is on the left of the observer "add," if on the right of the observer "subtract" the correction. A convenient method for determining the direction line for the gun is as follows: The gunner drives a stake at the gun position and rests a compass on it. He rotates the compass until the required azimuth is read against the index. The gun should not be at the gun position during this operation, since the compass can not be used within 30 feet of the gun, as it will be affected by the mass of metal. He then directs another number of the squad to drive a stake on this line. The gun is set up at the stake on which the gunner rested his compass and the second stake is used as the aiming point.

(4) *By the parallel line method.*—This method is simple and rapid and in many cases accurate enough for field use. When the gun is in position and the observer is a short distance on either flank where he can see the target and the gun position the direction can be determined by the following method: The observer estimates the distance to a point on the line gun-

target, which is opposite him. He selects an object on the terrain which is on the same side of the line gun-target, and which is at the same distance from the line gun-target, as himself. With a compass he reads the magnetic azimuth from his position to the selected object. This is the azimuth on which the gun is to be laid, and is transmitted to the gunner.

(5) *By stakes.*—The observer goes to the hill or to a position where he can see both the target and the area in which it is desired to locate the gun, places himself as nearly as he can judge by eye on the line from the target to the area in which the gun is to be located, and drives a stake. He then moves toward the desired gun position, keeping the target and the stake in view. When he has moved back as far as possible without losing sight of the target, he drives a second stake in line with the first and the target. He moves back to the desired gun position and drives another stake, in line with the two stakes he has driven, to mark the exact position of the gun. The gun is set up at this stake with the sight bracket against or over it, and the gun is laid by sighting on either of the stakes in front of the gun, with the deflection dial at zero. If the first two stakes are not visible from the gun position the observer continues to move back, driving additional stakes on the line of the first two until he finally reaches the gun position. If woods intervene between gun and target this same method may be used, extending the line of stakes through the woods. In cases where the gun is in position and the observer is on higher ground in rear of the gun he has an assistant go to the front and directs him in driving stake on line gun-target. This method is comparatively slow. In practically all situations one of the more rapid methods can be used.

(6) *By back azimuth*—(*a*) *Gun position not fixed.*—When the target is not visible from the desired gun position the observer goes forward to a position where he can see the target and the area in which it is desired to locate the gun. He places himself on the line between the target and the area in which the gun is to be located, as nearly as he can judge by eye. He drives a stake, rests a compass on top of it, and reads the azimuth to the target. He then converts the azimuth to back azimuth. Having converted the azimuth to back azimuth, he moves to the opposite side of the stake and rotates the compass until he reads the back azimuth against the index. He then has another member of the squad drive a stake at the

gun position on the line of back azimuth. The gun is set up at this second stake, and the stake on which the observer rested his compass is used as the aiming point. If the stake driven by the observer can not be seen by the gunner, the observer has a stake driven between himself and the gun on the line of back azimuth. He then moves to this stake, rests the compass upon it, rotates the compass until he reads the back azimuth again, and has another stake driven between himself and the gun position. This operation is repeated until a stake can be driven at the gun position and another stake which can be used as an aiming point has been placed.

(*b*) *Gun position fixed.*—The observer places himself where he can see both gun and target and as nearly on the line gun-target as he can estimate by eye. He drives a stake, places a compass on top of it, and reads the azimuth to the target. He converts the azimuth to back azimuth, moves to the opposite side of the stake and rotates the compass until he can read the back azimuth against the index. He then sights along the line of back azimuth. If the line of back azimuth passes through the gun position the stake is exactly on the line gun-target and may be used as the aiming point if visible from the gun position. If the line of back azimuth does not pass through the gun position the observer must move to the right or left, again read the azimuth to the target, convert it to back azimuth, and sight back along the line of back azimuth. He continues to do this until the line of back azimuth passes through the gun position. If the observer's stake can not be seen from the gun position he has additional stakes driven until one is visible. Time can often be saved by taking the first azimuth reading without the use of a stake. However, a stake should always be used as a support for the compass when taking or verifying the final reading. When the observer is provided with a compass which has sights that permit accurate alignment from front to rear, the compass can be used in the same manner as the alidade, and the azimuth need not be read or the back azimuth computed. This method is considerably faster and can be used with good results where a suitable compass can be obtained and where the compass can be rested on a steady mount of some kind.

(7) *By use of an alidade*—(*a*) *Gun position not fixed.*—The observer goes forward to the intervening crest as far as is necessary to see the target and takes a position from which

he can see the target and the area in which the gun is to be located. He drives a stake on the line between the target and the area in which the gun is to be located. He places an alidade (or straight stick) on top of the stake. He aligns the alidade accurately on the target, and then, sighting back over the alidade, indicates to a member of the gun squad the position at which a stake is to be driven which will mark the exact location of the gun. The assistant drives the stake where indicated. The gun is then laid for direction on the stake driven by the observer. If the stake driven by the observer is not visible from the gun position, he has additional stakes driven by the assistant between his position and the gun position on the rearward line established by the alidade, until a stake can be driven at the gun position. Any one of the stakes between the gun and crest can be used as an aiming point. If the ground at the gun position is of such nature as to prohibit the driving of a stake the assistant lays the stake on the ground.

(*b*) *Gun position fixed.*—The observer goes forward to a position on the crest where he can see both target and gun position and places himself on the line gun-target as closely as he can estimate by eye. He drives a stake on this line and places an alidade on top of the stake. He aligns the alidade accurately on the target and then sights back over the alidade. If the rearward line established by the alidade passes through the gun position the stake is exactly on the line gun-target and may be used as the aiming point. If the rearward line does not pass through the gun position the observer must move his stake to the right or left and repeat the operation of sighting first on the target and then to the rear until the alidade when aligned on the target is aligned also on the gun position.

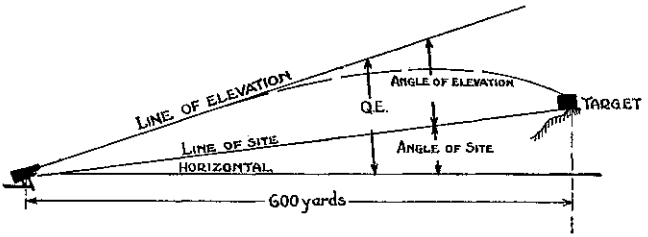
(8) *By map and compass method.*—In rare cases this method will be found applicable. The positions of gun and target are accurately plotted on a military map. The grid azimuth of the line gun-target is then measured with a protractor. This grid azimuth is then converted to magnetic azimuth and the gun laid on the magnetic azimuth obtained.

d. Elevation.—A projectile fired from a gun does not travel in a straight line. It begins its flight along the line in prolongation of the bore at the moment of firing and under the influence of gravity it falls, describing a gradual curve. If a gun is pointed directly at a target, and fired, the projectile will

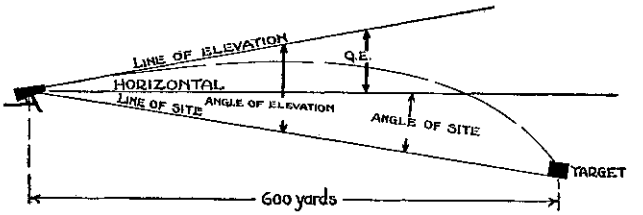
fall short of the target. Therefore, to hit the target the gun must be pointed above the straight line connecting the gun and target. (Fig. 16 ①.) This line is called the line of site, and refers to the site or location of the target and not to the sighting or aiming of the gun. All angles of elevation are measured from the line of site to the line of elevation. The angle of elevation is always the same for any given range, whether the target is higher or lower than the gun. In laying a gun in elevation when the target is not visible, some mechanical means is necessarily employed. The angle at which the gun is laid may best be measured from the horizontal, as the horizontal can always be established by the spirit level of the quadrant sight. Computation of the elevation data therefore consists of determining the angle at which it is necessary to lay the gun above the horizontal. The angle between the axis of the bore when the gun is laid and the horizontal is called the angle of "quadrant elevation" (abbreviated Q. E.). When the gun is fired the projectile begins its flight on a line of departure which makes an angle of 5.3 mils with the line of elevation. This angle of 5.3 mils is called the angle of jump. The angle between the line of departure and the horizontal is called the quadrant angle of departure. The ranges and elevations given in the fire-control tables for this gun are based on angles of elevation used in actual firing. For this reason the use of the tables does not require any correction for jump. The angle of site may be a plus, a negative, or a zero angle of site, depending on whether the target is above, below, or on the horizontal through the gun position. The Q. E. is always the algebraic sum of the angle of site and the angle of elevation. (Fig. 16, ① and ②.)

e. Determination of angle of site of the target.—The most accurate and convenient means of determining the angle of site of a target is by use of an angle-of-site instrument. A sitogoniometer is a very convenient instrument for doing this. (Chapter 1, Part Two, Basic Field Manual, Volume III.) If no instrument is available, the following method can be used with fair accuracy: The observer first locates a point near the target which is at the same level as his own position. If possible, this point is usually selected so as to appear directly above or below the target. He then estimates the vertical distance which he is above (below) the gun. By applying this vertical distance below (above) the point first

selected, he can now locate a point which is approximately on the same level as the gun. The vertical angle in mils between the point last selected and the target is then measured with the field glasses. The angle measured will be equal to, less than, or greater than the angle of site to be set off on the sight of the gun, depending upon whether the observer is the same distance, a greater distance, or a less distance than



① Target higher than gun



② Target lower than gun

FIGURE 16.—Elevation

the gun is from the target. This measured angle varies from the angel of site to be applied on the sight as the ratio $\frac{\text{Distance observer-target}}{\text{Distance gun-target}}$ and may be corrected by applying this factor. The difference in elevation between the gun position and the observer will usually be so small in relation to the range that it can be ignored.

Example: The observer is 200 yards in front of the gun; the observer is 10 yards higher than the gun. He selects a point near the target on the same level as himself. He selects a second point which he estimates to be 10 yards below the first point and measures with his mil scale the vertical angle between this second point and the target. He reads this angle

second point to target to be 20 mils. Multiplying this reading by the factor

$$\frac{\text{Distance observer-target}}{\text{Distance gun-target}}$$, he gets $\frac{10}{12} \times 20 = 17$ mils,

the angle of site to be applied on the sight. If a map is being used in computing data the angle of site can be computed by the mil formula M equals $\frac{1000W}{R}$, in which M is the angle in mils, W is the difference in yards in elevation between gun and target, and R is the range gun-target. The angle of site of a target is a plus, a minus, or a zero angle of site, depending on whether the target is above, below, or on the same level as the gun. Except for computing of very accurate data an angle of site of 5 mils or less is disregarded.

f. Determination of range.—Range, in most cases, is estimated by eye. It may be determined by using a range finder, if one is available, or may be determined from a map or by plotting. The more elaborate methods of determining range are slow and seldom of use in the field.

g. Laying the gun for elevation.—The quadrant sight is so constructed that the Q. E. of the target is computed mechanically. The procedure of laying the gun is as follows:

(1) Set the angle-of-site dial at the angle of site of the target.

(2) Set the range dial with the graduation corresponding to the range to the target opposite the index on the angle-of-site dial.

(3) Center the bubble in the level vial by manipulating the elevating mechanism of the carriage.

Discussion.—Assume that a target has an angle of site of plus 10 mils and is at a range of 1,000 yards. The gun must be laid with a Q. E. equivalent to 10 mils plus 1,000 yards. When the angle-of-site dial is set at plus 10 mils, its index is moved to the left. No other part of the sight is moved by this setting since the angle-of-site dial is a free moving part. Now when the 1,000-yard graduation on the range dial is set opposite the index on the angle-of-site dial, the level vial is moved through an angle which is the sum of the angle of elevation equivalent to 1,000 yards and 10 mils. The sum of the two angles in this case is (38 plus 10) 48 mils. When the bubble is centered as described in step (3) above, the barrel is elevated 48 mils above the horizontal. Had the angle of site

been minus 10 mils and the angle-of-site dial set accordingly, its index would have moved to the right. Now when the 1,000-yard graduation of the range dial is set opposite the index of the angle-of-site dial, the level vial is moved through an angle of (38 minus 10) 28 mils. When the bubble is centered by manipulating the elevating mechanism, the barrel is elevated 28 mils above the horizontal.

h. Minimum range.—(1) *Definition.*—Minimum range is the least range setting at which the projectile will clear the mask when the gun is fired, from a given position, on a target with a given angle of site.

(2) *Practical application.*—(*a*) To determine the minimum range when the gun is first put in position, the gunner must execute the following steps:

1. Set the range dial at the range to the mask with the site-corrector ring at zero.
2. By turning the elevating handwheel, lay the gun so that the horizontal crossline of the collimator just clears the top of the mask.
3. By turning the range dial, center the bubble.
4. Set the angle-of-site dial at the angle of site of the target. Read the minimum range on the range dial, opposite the index on the angle-of-site dial, and announce the minimum range to the gun commander.

(*b*) The minimum range having been determined to be less than the range to the target, the gun commander then issues his fire order for indirect laying and proceeds to engage the target. When a target has an angle of site less than 5 mils, the angle is disregarded (except when data are very accurately computed) because it is extremely difficult for an observer to measure an angle of site within 5 mils without instruments.

(*c*) When changing from one target to another, the gun position not being changed, no change is made in the setting of the angle-of-site dial unless there is a difference of more than 5 mils between the angles of site of the two targets. When a new target is selected in the same direction as the previous target and the difference between the angles of site is greater than 5 mils, the gunner determines the minimum range as follows:

1. Set the angle-of-site dial at the setting for the previous target.

2. Set the range dial at the minimum range for the previous target.
3. Turn the angle-of-site dial to the angle of site of the new target and read the minimum range.

Discussion.—When a mask such as a hill, wood, or heavy brush intervenes between the gun and target it is necessary to know whether the gun can fire over the mask and engage the target. Assume a gun to be firing over a crest so that the projectiles will barely clear the crest, without considering the gun as engaging any particular target. The trajectory may be considered fixed, since the piece is fired with a fixed elevation (the one which barely clears the crest), and the projectiles continue their flight beyond the mask until they strike the ground. (Fig. 17 ①.) The point at which they will strike the ground depends on the height of the ground, whether the ground rises, falls away, or is level. The slope of the terrain fixes the slope of the line of site, which is expressed by the angle of site. When a particular target is engaged, the angle of site to be used is involved in the determination of whether or not a mask can be cleared, because the angle of site is in reality the elevation of the target with respect to the gun and involves the slope of the terrain beyond the mask. It can then be said that the distance from the gun to the intersection of this lowest trajectory with the line of site is the least range which can be used from the given gun position, with the given angle of site, and have the projectile clear the mask. Figure 17 ①, ②, and ③ illustrates the effect which the slope of the terrain beyond the mask has on this least range. If it is known what elevation is required to clear a particular mask, then, in reality, one knows whether or not any given elevation will clear the mask. When indirect laying is employed, the piece is laid by the application of the angle of site and the range, rather than by the direct application of the Q. E. Therefore, the elevation required to clear a mask should be obtained in terms of range and angle of site. These two quantities are dependent on each other for their values in making up a given Q. E. For convenience one of them, the angle of site, is fixed for a given target. This is done by deciding to use a certain angle of site (the angle of site of the target being engaged) and then proceeding to determine the range which, coupled with this angle of site, will give the piece the proper elevation to cause the projectile just to clear the mask. In the operation of deter-

mining this least range which will clear a mask, the piece is laid so that a round, if fired, would just clear the mask. (Par. *h*(2) above.) Then, by manipulating the quadrant sight (centering the bubble and setting the angle of site), the elevation given the piece is measured in terms of yards on the range dial. The reading found on the range dial after this operation is what is called the "minimum range." If this range is less than the range to the target, the target can be engaged. The gun can be given additional elevation above that necessary to clear the mask. (Fig. 17④.) If the minimum range is greater than the range to the target, the target can not be engaged. (Fig. 17⑤.) The gun can not be given an elevation below that required to clear the mask, because a lower elevation will probably cause the shell to burst on the mask. In this case it will be necessary to move the gun to a position where the minimum range will be less than the range to the target.

(3) *Precautions during firing.*—When the minimum range has been determined the gun has the least elevation which will permit a projectile to clear the mask. It is mandatory that the gun commander exercise the greatest care that he does not order a range setting which is less than the minimum range. If he does order such a setting, the gunner will inform him that the range he has ordered is less than the minimum range.

Example.—The minimum range has been determined as 650 yards. The first round, fired with a sight setting of 750, bursts beyond the target. The gun commander, being intent on bracketing, orders a setting of 550 for the next round. The gunner informs him that the minimum range is 650. The gun commander then orders a round fired with a range setting of 650. If this round bursts beyond the target, it is necessary that the gun be moved to a new position.

i. Use of the telescopic sight in indirect laying—(1) *Calculation of the firing data.*—Since the telescopic sight is not equipped with angle-of-site dial or spirit level the Q. E. is necessarily calculated by the gun commander. With the quadrant sight this calculation is unnecessary as the data are computed mechanically. To determine the Q. E. to be used, proceed as follows: Estimate the range to the target. Refer to the range table and determine the angle of elevations which correspond to the estimated range. Measure the angle of site. Add algebraically the angle of elevation and the angle of site. The result is the Q. E. in mils. Again refer to the range table and

determine the range, in yards, which corresponds to this angle. This is the range to be set off on the sight when the gun is laid.

Example 1.—The range to the target is estimated to be 800 yards and the angle of site is "plus 10." The range table shows the angle of elevation for 800 yards is 28 mils. In this case both the angle of elevation and the angle of site are positive angles. Add the angle of elevation (plus 28) and the angle of site (plus 10). The sum is 38 mils, which is the Q. E. in mils. To convert this to yards refer to the range table, which shows that 38 mils is the angle of elevation for 1,000 yards. When the gun is laid, set off 1,000 on the range dial of the sight.

Example 2.—Assume the estimated range to the target to be 1,000 yards and the angle of site to be "minus 10." The range table shows that the angle of elevation for 1,000 yards is 38 mils. In this case the angle of site is a negative angle. The algebraic addition of the two angles gives a Q. E. of 28 mils. The range table shows that 28 mils is the angle of elevation for 800 yards. When the gun is laid, set off 800 on the range dial of the sight.

(2) *Laying the gun.*—The telescopic sight can be used in indirect laying, though its use in this manner is purely an emergency method and is ordinarily resorted to only when the quadrant sight is lost or broken. In using this sight it is necessary that the horizontal be determined in order that the Q. E. may be measured therefrom. This result is obtained by means of a plumb line, the gun, and a stake. The rear face of the breechblock cap of the M1916 gun forms a right angle with the axis of the bore. Therefore, when the rear face of the breechblock cap is vertical the axis of the bore is horizontal. To lay the gun proceed as follows:

(*a*) Lay the gun for direction.

(*b*) Hold a plumb line (which can be made by tying a stone to a piece of string) against the rear face of the breechblock cap and raise or lower the barrel by turning the elevating handwheel until the rear face of the breechblock cap, from top to bottom, is in contact with the plumb line when the line is vertical. The rear face of the breechblock cap will then be vertical and the barrel will be horizontal.

(*c*) Set the range dial at zero. When the sight is at zero the line of sighting is parallel to the bore. When the sight is

at zero and the barrel is horizontal the line of sighting is also horizontal.

(*d*) Set out an aiming stake in front of the gun in such position that it is visible in the field of vision of the sight and slightly to the left of the vertical line when the deflection dial is at zero. Turn the deflection dial until the vertical line is in line with the stake. The stake is set to the left to prevent the projectile striking it. It may be set to the right, but left is preferable.

(*e*) Mark the stake where the line of sighting, as established by the horizontal line of the sight, intersects the stake. This marks the horizontal.

(*f*) Set off on the range dial of the sight the range determined in the calculation of the firing data. Bring the intersection of the crosslines on the mark on the stake by turning the elevating and traversing handwheels. Since the gun has previously been laid for direction, the movement of the traversing handwheel is slight, being merely enough to bring the intersection of the crosslines on the mark on the stake after the range has been set off on the range dial.

(3) *Determining the least Q. E. which will safely clear a mask.*—After the mark denoting the horizontal has been made on the stake, as described in (2) above, the least quadrant elevation which will safely clear a mask may be determined as follows:

(*a*) Set off the range to the mask on the range dial.

(*b*) Lay the gun, by means of the elevating handwheel, so that the horizontal line of the sight just clears the top of the mask.

(*c*) Turn the range dial until the horizontal line of the sight is aligned on the mark on the stake.

(*d*) Read the range on the range dial. This reading expresses, in yards, the least quadrant elevation which can be used and have the projectile clear the mask.

79. **Overhead fire**—*a. General.*—Since it will rarely be possible to fire through gaps in our own line, much of the support accorded to our troops is of necessity overhead fire; that is, fire directed over the heads of friendly troops. After consideration has been given to those factors which enter into all firing and which make it improbable or impossible for all shots to hit the exact spot desired, it is possible to lay down certain rules under which overhead fire can be employed with

safety. Conversely, these rules can be employed to determine when such fire is unsafe and is not to be employed. The factors which are to be taken into consideration to insure that all shots clear the heads of friendly troops are enumerated in order to show how safety rules are determined.

(1) *Dispersion of the shot group.*—(*a*) All other factors being disregarded, every shot does not follow the same path, due to errors in elevation of the gun, variations in the manufacture of ammunition and gun, the condition of the gun, and the atmospheric conditions. These variations have been determined by test and the vertical and horizontal dispersion of the cone tabulated for all ranges. In addition to the dispersion of the shot group, which may be classed as mechanical, it is also necessary to consider the human element; that is, errors made by the gun commander in determining the following:

1. The range to the target.
2. The range to the troops.
3. The vertical interval between gun and target.
4. The vertical interval between gun and troops.

(*b*) If fire is adjusted, the errors (*1*) and (*3*) are eliminated and (*2*) and (*4*) are greatly reduced since a gauge for comparison is available in the target itself.

(2) *The safety clearance.*—To insure the safety of friendly troops, it is necessary to have sufficient clearance between the lowest shot and the ground to allow for errors in range estimation, for the height of the men, for slight inequalities in the surface of the ground, and for an ample margin of safety. A table has been prepared which takes these factors into consideration and gives, for each range, the minimum clearance of the mean trajectory. For convenience these clearances are expressed in terms of the angles they subtend at the gun and are known as safety angles. Going a little further, and assuming gun, troops, and target to be on the same straight line, if the angle of elevation for the range to the troops be added to the safety angle the result will be the minimum angle of elevation permissible when the troops are at the range indicated. This angle of elevation may be converted to a range in yards which is the least range permissible.

b. Overhead fire with direct laying.—Direct overhead fire is that overhead fire which is delivered by the employment of direct laying. Two distinct situations arise in the delivery of

direct overhead fire. One is where the troops are stationary, as in a defensive position. The other is where the troops are advancing, as in the attack. Each situation requires a different method to determine whether overhead fire can be delivered and for what length of time.

(1) *Troops not advancing.*—(*a*) Determine the range to the friendly troops.

(*b*) Find this range in column 1 of the overhead fire table. (*f* below.)

(*c*) Find the corresponding range on the same line in column 3 of the overhead fire table. This will be the least range at which it is permissible to fire over the friendly troops in the position they are occupying at the time.

(2) *Troops advancing.*—(*a*) Determine the range to the target.

(*b*) Find this range in column 3 of the overhead fire table.

(*c*) Find the corresponding range in column 1 of the overhead fire table. This will be the range to which troops can safely advance. When the friendly troops reach this range, fire must cease or be lifted.

(3) *Rule of thumb.*—(*a*) In cases where the fire-control tables are not accessible the following rule of thumb, based on the table of overhead fire, may be used:

1. Set the range dial at the range to the target and lay the gun on the target.
2. Increase the sight setting by 500 yards.
3. Look through the sight and note the point where the line of aim strikes the ground. If this point is ahead of the friendly troops it is safe to fire.

(*b*) Due to the fact that the greatest range graduation on the telescopic sight is 2,000 yards, this method is limited in application and should be used only in case no fire-control tables are available.

c. Overhead fire with indirect laying.—Indirect overhead fire is that overhead fire which is delivered by the employment of indirect laying. As in direct overhead fire, separate calculations are made for troops which are stationary and troops which are advancing.

(1) When the troops are visible to the gunner, and are not advancing, the following method should be used:

(*a*) Determine the range to the troops.

(*b*) Set the angle-of-site dial at the safety angle for troops at that range. (The safety angle may be found in column 2 of the overhead fire table.)

(*c*) Set the range to the troops on the range dial against the index of the angle-of-site dial.

(*d*) Lay the horizontal line of the collimator on the troops, with the sight set as above, by means of the elevating and traversing mechanism.

(*e*) Center the bubble by turning the range dial without changing the position of the gun.

(*f*) Set the angle-of-site dial at the angle of site of the target.

(*g*) Read the range on the range dial now opposite the index of the angle-of-site dial. This will be the least range at which it is safe to fire over the friendly troops. If the target is nearer than the range shown on the range dial it is not safe to fire. It will be seen that this method is similar to the ordinary method of determining the minimum range, except that the safety angle is set on the angle-of-site dial before the other operations are performed.

(2) When the troops are not visible to the gunner, and are not advancing, the following method should be used:

(*a*) Measure the angle of site of the target.

(*b*) Determine the range to the target.

(*c*) Calculate the Q. E. for the target.

(*d*) Measure the angle of site of the troops.

(*e*) Determine the range to the troops.

(*f*) Calculate the Q. E. for the troops.

(*g*) Subtract the Q. E. of the troops from the Q. E. of the target. If the angular difference between the two is equal to, or greater than, the safety angle for troops at that range (see overhead fire table), it is safe to fire. If the angular difference between the two is less than the safety angle for troops at that range it is not safe to fire.

(3) When troops are advancing, the following method should be used to determine how far the troops can advance before it is necessary for the fire to cease or be lifted:

(*a*) Determine the range to the target.

(*b*) Find this range in column 3 of the overhead fire table.

(*c*) Find the corresponding range in column 1, on the same line. This will be the range to which troops may safely advance

before fire must cease or be lifted, when the troops are on the line of site and the ground is level or has a uniform slope. When a hill or pronounced rise in the ground lies between the gun and the target on the ground over which the troops must advance, the troops will be nearer the trajectory than when the ground is level or has a uniform slope from gun to target. Therefore, this rise in the ground is necessarily considered and calculation made to determine whether it will be safe to fire when the troops are on the hill or rise in the ground. This is done by the same method as used when troops are stationary, using the hill or rise as the position of the troops.

d. General rules.—The following general rules will be observed in the delivery of overhead fire:

(1) The laying of the gun will be carefully checked by the gunner before firing each round.

(2) The target and the limit of safety will always be visible to the observer.

(3) Fire will cease or be lifted when troops reach the limit of safety.

(4) When overhead fire is to be delivered from the time troops begin to advance, it will be determined whether it is safe to fire over them in their starting position. It is then necessary to determine how far they can advance before the fire must cease or be lifted. Both calculations are necessary.

(5) Required safety angles must not be lessened.

(6) When practicable, friendly troops should be informed when overhead fire is to be delivered over them.

(7) When practicable, depression stops should be used to prevent the muzzle being accidentally lowered below the limit of safety.

(8) *Overhead fire is prohibited when the troop distance is less than 400 yards,* unless the difference in elevation of gun and friendly troops makes it perfectly evident that it is safe to fire.

e. Duties and training of the gun commander.—The delivery of overhead fire requires the highest degree of exactness and accuracy, and no observer or gunner will be allowed to execute this kind of fire unless he is thoroughly instructed and proficient in it. The gun commander is responsible for the rules of safety. When direct laying is employed the gun commander will be at the gun position and supervise the gunner's laying.

When indirect laying is employed, the gun commander, having determined the firing data, will take such position that he will be able to see the position of the friendly troops, the target and the limit of safety. He gives the orders for opening and ceasing fire. He must thoroughly understand the rules for overhead fire and their application sufficiently well to repeat them without reference to written notes. He is given practice in applying these rules to assumed situations. The instructor conducts the observers, receiving instruction in overhead fire, to gun positions from which overhead fire is assumed to be delivered against targets indicated by the instructor. The instructor explains the rules and then requires the observers to determine whether or not it would be safe for the gun to fire if troops were at different positions along the line gun-target. The determination of the limit of safety is checked by the instructor.

f. Overhead fire table.—The table given below shows distances to troop positions, safety angles, and least permissible ranges. It is used as described in this section.

Table for overhead fire, high-explosive shell, Mk. II, muzzle velocity 1,276 f/s

(1) Troop distance	(2) Safety angle	(3) Corresponding range [1]	(1) Troop distance	(2) Safety angle	(3) Corresponding range [1]
Yards	*Mils*	*Yards*	*Yards*	*Mils*	*Yards*
400	23.5	925	1,000	24.9	1,450
500	22.4	975	1,100	26.6	1,575
600	21.3	1,050	1,200	28.2	1,675
700	21.3	1,125	1,300	29.8	1,775
800	22.1	1,225	1,400	31.7	1,900
900	23.3	1,350	1,500	33.7	2,000

[1] In even figures to the nearest 25 yards above the exact range.

80. Fire control and adjustment.—Fire control is the regulation of fire by the gun commander. It enables him to bring fire on a designated target, to open and cease fire at will, to control the expenditure of ammunition, and to engage new targets. The gun commander controls fire by orders, commands, or signals which express the firing data to be used. When direct laying is employed he transmits the firing data by voice,

as his position is at, or very near, the gun position. Whenever possible he will issue the firing data in the form of an oral fire order. In exceptional cases the gun commander may lay the gun himself or will give a detailed explanation to the gunner instead of issuing a formal fire order.

a. Fire orders—(1) *Initial fire orders.*—(*a*) The initial fire orders (which contain the data for laying the gun for the first round) will contain the information shown below and will be given in the following sequence:

1. Type of shell to be used.
2. Deflection.
3. Angle of site (in case of indirect laying).
4. Range.
5. Aiming point.
6. Number of rounds to be fired.

(*b*) The words "type of shell," "deflection," "range," etc., are understood and not spoken.

Example.—Assume that an initial fire order for direct laying is to contain the following data: A high-explosive shell is to be used with a deflection of zero and a range of 900 yards; the aiming point is the base of a small pine tree directly to the front and one round is to be fired. The order would be expressed as follows:

HIGH EXPLOSIVE.
ZERO.
900.
TO YOUR FRONT, SMALL PINE TREE; BASE OF TREE.
ONE ROUND.

The deflection will always be announced, even if it is zero. Gunners and their assistants are trained to receive and execute fire orders in a fixed sequence and any variation or omission will cause delay and confusion. Unnecessary words are omitted.

The command (***So many***) ***rounds*** also indicates that the gun is to be loaded at once, and to be fired when laid.

(2) *Typical fire order for indirect laying.*—Assume that a high-explosive shell is to be used, that the target is 15 mils to the right of a natural aiming point which is the left edge of a lone pine tree to the front (deflection, right 15 mils);

that the target has a minus 10 angle of site and a range of 1,300 yards; one round is to be fired. The fire order would be:

HIGH EXPLOSIVE.
RIGHT 15.
MINUS 10.
1,300.
TO YOUR FRONT, LONE PINE TREE, LEFT EDGE OF TREE.
ONE ROUND.

(3) *Subsequent orders.*—Subsequent fire orders contain only the data which are to be changed, and the number of rounds to be fired. To enable the observer to order the proper correction for errors in range he should remember the range with which the last round was fired, because, when orders are given orally, and when the signals used render it possible, he commands the actual range setting to be set off on the range dial. It is not necessary for him to remember the last setting of the deflection dial because, in making corrections, he uses the last setting as a zero; in other words, he commands the correction to be made from the setting used for the preceding round.

Example.—The first round was fired with the deflection dial set at *left 14* and the range dial set at 1,400; the observer wishes to fire the second round with a change which will move the burst 2 mils to the right and at a range of 1,200 yards; his fire order is:

RIGHT 2.
1,200.
ONE ROUND.

The gunner moves the deflection dial to *left 12*, the range dial to 1,200, and relays the gun. If it is desired to change only the range for the third round, and the range desired is 1,300 yards, the fire order is:

1,300.
ONE ROUND.

If it is found that the range and deflection are correct, the observer can cause a number of rounds to be fired; as, for example, five. The fire order is:

FIVE ROUNDS.

b. Arm-and-hand signals—(1) *To change deflection.*—Thrust the hand horizontally to the full extent of the arm in the direction in which the change in deflection is to be made, beginning

the thrust at the shoulder with the palm down. Each thrust with the fist closed signifies 1 mil; with the hand open, 5 mils.

(2) *To increase (decrease) range.*—Thrust the fist upward vertically from the shoulder to the full extent of the arm once for each increase of 25 yards; thrust it downward vertically in the same manner for each decrease of 25 yards.

(3) *To fire (so many) rounds.*—Extend the arm toward the gunner for whom the signal is intended, with the hand raised and the palm toward him; expose the fingers to indicate the number of rounds to be fired, 1 finger for 1 round, 2 fingers for 2 rounds, and so on. The gunner or a designated assistant receives and repeats back all signals to the gun commander (observer).

c. Kinds of fire.—Fire is divided into two classes; fire for adjustment and fire for effect. Fire for adjustment is that class of fire used to bring the center of impact on the target; it is treated at length in *e* and *f* below. Fire for effect is that class of fire used to destroy, immobilize, or neutralize a target. It is delivered after fire has been adjusted. The number of rounds to be fired to effect the destruction of a target must be decided by the gun commander. The firing of a small number of rounds in a series is better than firing the entire number of rounds in a group, as it permits the observer to make slight adjustments and prevents wild shooting. To order fire for effect the gun commander commands: ***(SO MANY) ROUNDS.*** The command ***Fire for effect*** is not used.

Example.—A gun commander decides to use 15 rounds to destroy a target, fire having been adjusted. He commands ***Five rounds*** and observes the bursts. He makes any corrections that he deems necessary and again orders ***Five rounds.*** If satisfied, he again orders ***Five rounds.*** The three series should follow each other without unnecessary pause. As the gun is used against definitely located targets and not to cover areas, traversing, searching, and oblique traversing are not standard classes of fire for the 37-mm gun. There are no fixed commands for these classes of fire, which, if desired in unusual cases, can be ordered by detailed instructions to the gunner.

d. Sensings—(1) *General.*—When an observer senses a burst from a round fired, he determines the deflection error; that is, how many mils the burst is to the right or left of the target, and whether it is an "over" or a "short"; that is, whether

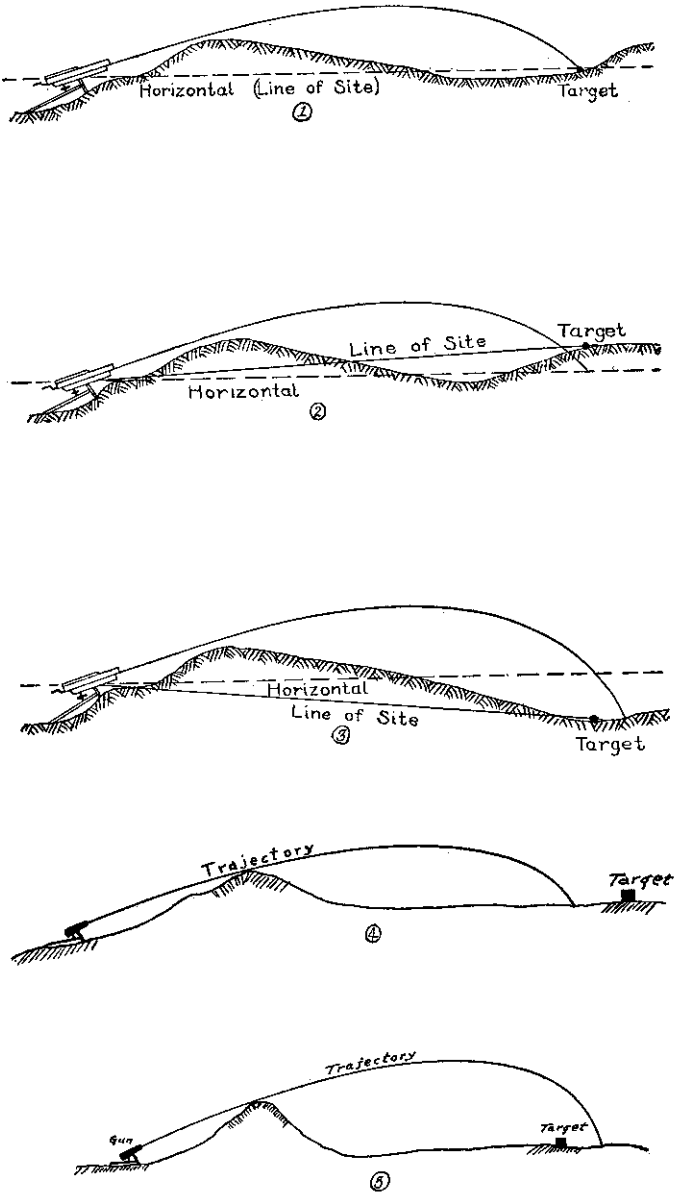


FIGURE 17.—Minimum range

the burst is beyond or short of the target. He may be able to sense the round for deflection but not for range, in which case another round should be fired with the deflection correction applied and with the same range as the preceding round. In sensing a round the observer senses first for deflection and next for range.

(2) *Observer at the gun position.*—The best position for the observer is at the gun position. From this position his deflection sensing and the deflection correction to be made on the sight are the same. He can also exercise better control over the gun squad when at the gun position.

(3) *Observer in front or rear of the gun position and on the line gun-target.*—Next to the gun position, the best place for the observer is in front or rear of the gun position and on the line gun-target. However, from such a position his deflection sensing is not the same as the deflection to be set off on the gun.

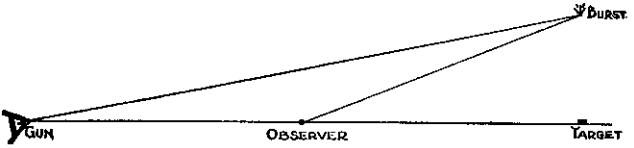


FIGURE 18.—Deflection sensing

If he is in rear of the gun the deflection sensing will be less than the deflection to be set off on the gun; if he is in front of the gun the deflection sensing will be greater than the deflection to be set off on the gun. (Fig. 18.) By practice the observer is able to determine the proper allowance to make. If he is halfway between the gun and target his deflection sensing will be twice the correction to be made on the sight; if the gun is halfway between the observer and the target his deflection sensing will be half the correction to be made on the sight; other distances will give other ratios. (Fig. 19.) However, the observer will usually be close enough to the gun position to obviate the necessity of a correction for the distance of the observer from the gun.

(4) *Observer to the flank, to the flank and forward, or to the flank and rear.*—(*a*) In each of these cases there will be an additional error due to the fact that the deflection sensing

varies as the observer moves to the right or left; that is, the positions of the target and the point of impact with relation to each other seem to change as the observer changes his position.

Example.—In Figure 19 the observer at A reads the actual deflection which should be set off on the sight. If he moves to B he sees the burst as if it were directly in line with the target; a correction for deflection is apparently unnecessary.

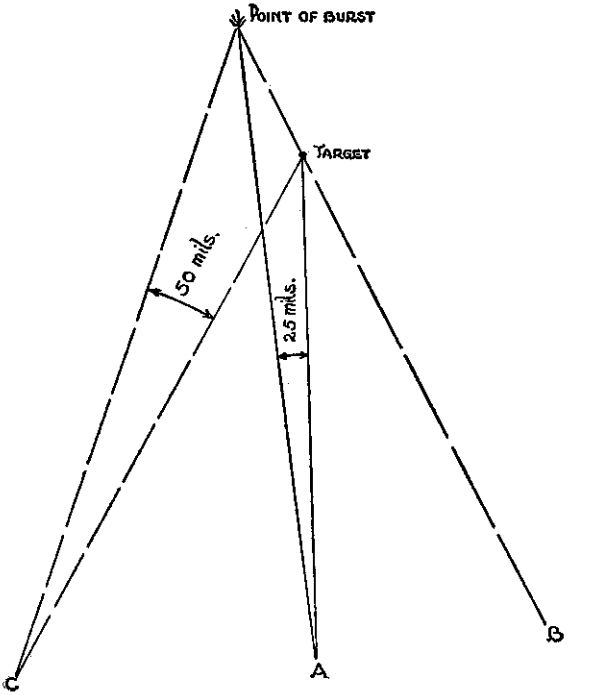


FIGURE 19.—Deflection sensings

If he moves to C he reads a deflection that is much greater than the correction to be set off on the sight. No formula has been devised which is satisfactory for use in the field.

(*b*) Upon taking a position off the line gun-target the observer should at once estimate where the line gun-target lies on the ground and read the deflection from this line to the bursts. As bursts having errors in range will appear to be to

the right or left of the target, the observer should also estimate where a line perpendicular to the line gun-target and passing through the target lies. Having estimated where the line lies on the ground, the observer should consider all bursts between himself and this line to be "shorts," and all bursts on the far side of the line as "overs." An observer should always endeavor to avoid an observation post off the line gun-target.

e. Adjustment for range.—Two methods are used in adjusting for range. They are known respectively as the bracketing and creeping methods. The bracketing method is used under almost all conditions. The creeping method may be used in overhead fire.

(1) *Bracketing method.*—(*a*) The bracketing method is the one usually employed in adjusting fire. In this method the target is bracketed between an "over" and a "short." The target is kept between two ranges, one increasing and the other decreasing, until the center of impact is on the target. A target is said to be bracketed when one "short" and one "over" have been obtained. Adjustment of fire by the bracketing method is executed as described hereinafter. The range to the target is estimated as accurately as possible and a round is fired with this setting. If the burst is observed to be an "over" the range setting is decreased 200 yards and another round fired with this new setting. If this is a "short" the third round is fired with a range setting which is the mean or average of the two previous range settings. Subsequent rounds are fired with range settings which are the mean of the last "short" and the last "over." If the first burst is a "short" the range setting is increased 200 yards and another round is fired. Subsequent rounds are fired with range settings which are the mean of the last "short" and the last "over." The distance from the target of the "short" or "over" is immaterial, and need not be estimated or considered by the observer. After the bracket is obtained the range is increased or decreased in steps of 100, 50, and 25 yards, until the center of impact is on the target. If the bracket is not obtained by the second round, the range setting is again increased or decreased 200 yards and another round fired. Occasions when the bracket will not be obtained by the second round will be rare.

Example (fig. 20).—The range to the target is estimated to be 1,100 yards and the first round is fired with this setting. The burst is observed to be a "short." The range setting is

increased 200 yards and the next round is fired with a setting of 1,300. The burst is observed to be an "over." The bracket is now established. The range setting for the third round is the mean of the "short" (1,100) and "over" (1,300) and is fired with a setting of 1,200. The third round is observed to be an "over." The fourth round is fired with a setting of 1,150, which is the mean of the last "short" (1,100) and the last "over" (1,200). The fourth burst is observed to be a "short." The range for the fifth round is 1,175, which is the mean of the last "short" (1,150) and the last "over" (1,200). The fifth round bursts on the target. This may be verified by two additional rounds and fire for effect opened, or fire for effect may be opened without verifying rounds.

(*b*) Adjustments of less than 25 yards are used only when making a very fine adjustment of fire. As the probable error of the gun is about 25 yards at most combat ranges, the dispersion will cover the target. Experience has proved that the

FIGURE 20.—Bracketing method

bracketing method is the quickest, most accurate and economical method of adjusting fire. Attempts to estimate the distance between a burst and the target and to bring the next burst on the target are seldom successful, due to the inability of observers to estimate accurately the distance between two points on the line gun-target. The bracketing method eliminates the necessity of doing this. The observer need merely determine whether a burst is a "short" or an "over." The method is applicable to practically all situations. Even when firing at a target on the crest of a hill the "shorts" can be observed and all unobserved bursts are treated as "overs."

(2) *Creeping method*—(*a*) *General.*—This method is used when bursts must approach the target from but one direction. (Fig. 21.) It is seldom used except in the adjustment of overhead fire when friendly troops are so close to the target that the bracketing method would be dangerous. In such case the first round is fired with a sight setting which will insure the burst being beyond the target; subsequent rounds are fired

with sight settings which will insure that the shells do not burst short of the target. The creeping method is not the normal method of adjusting fire and should not be used when the bracketing method can be used with safety. It is slower than the bracketing method and usually requires a greater expenditure of ammunition. The highly desirable feature of the creeping method is its factor of safety in certain situations, particularly in adjusting overhead fire.

(*b*) *Determination of the initial range setting.*—The determination of the range setting to be used for the first round is important since it must burst on the desired side of the target. It is determined in the manner described below. An "over" being desired in overhead fire, the observer estimates the extreme range to the target; that is, he estimates that the target is not more than a certain distance from the gun. He then uses a range setting which is greater than this extreme estimated range.

Example.—Friendly troops are close enough to the target to render bracketing unsafe. The observer estimates that the target is 1,000 yards from the gun and certainly not more than 1,100. He uses 1,100 as the base and adds 100 to make certain that the first round will burst beyond the target. He orders a range of 1,200 for the first round.

(*c*) *Adjustment of fire.*—The error of every burst must be estimated when adjusting fire by the creeping method. The first round is fired with a range setting which will insure the burst being on the desired side of the target, which in the usual case, overhead fire, is the far side. The observer estimates the amount of the error in yards and halves it. If the first burst was an "over" as intended, the halved error is deducted from the initial range setting and a round is fired with the new range. The error of the second burst is estimated, halved, deducted, and another round fired. This is continued until the center of impact is on the target, when fire for effect is opened. If at any time a burst is obtained on the wrong side of the target, the next round is fired with a change equal to half the change made for the last observed round.

Example.—The gun commander is delivering overhead fire. He estimates that a range setting of 1,350 will insure the first burst being beyond the target, and fires a round with that setting. (Fig. 21.) He estimates the burst to be 300 yards beyond the target. Half of this error is 150 yards. He de-

ducts 150 from 1,350 and fires the next round with a setting of 1,200. He estimates the burst of the second round to be 100 yards beyond the target. Half of this error is 50. He deducts 50 from 1,200 and fires the third round with a setting of 1,150. He estimates the burst to be 100 yards beyond the target. He deducts 50 from 1,150 and fires the fourth round with a setting of 1,100. The burst is observed to be a "short" (on the wrong side of the target). The observer makes a change equal to half the change made for the previous round (which was 50) and fires the fifth round with a setting of 1,125. It bursts on the target. This is verified by two additional rounds, found to be correct, and fire for effect is opened.

f. Adjustment for deflection.—The observer should have the zero of the horizontal mil scale of his glasses trained on the target before the shell bursts. The deflection error is sensed at the instant the shell bursts. If this is not done, sensing may become difficult owing to the smoke cloud being blown to one side or dissipated. The deflection error as sensed is imme-

FIGURE 21.—Creeping method

diately changed to a deflection correction and given to the gunner in an adjustment order.

Example 1.—The burst of a shell is sensed as 14 mils left of the target. The observer orders ***Right 14,*** thus moving the next burst 14 mils to the right. The observer orders the actual correction to be made, regardless of the reading on the deflection dial.

Example 2.—The gunner has made the correction previously ordered, and the deflection dial is set at *right 14.* A round is fired and the observer senses the burst to be 3 mils left of the target. He orders ***Right 3.*** The gunner sets the sight at *right 17,* thus giving the gun additional 3 mils deflection to the right. Another round is fired and the observer senses the burst to be 1 mil right of the target. He orders ***Left 1*** and the gunner sets the deflection dial at *right 16,* thus moving the gun 1 mil to the left. The gunner, of course, relays on the aiming point after each change of sight setting, by turning the elevating and traversing handwheels.

81. Special methods of fire—*a. Firing against moving targets.*—The 37-mm gun can be used against moving targets such as tanks and armored cars, but the methods usually employed for firing on point targets are too slow for this type of fire. Because of the target's ability to make changes of direction and speed, it is necessary for the observer to make estimates of angular speeds and to announce changes of deflection and range which will keep the fire on the target. The method employed can best be described by outlining the duties of the various members of the squad during firing.

(1) *The observer.*—The observer has the problem of target designation, range and deflection estimation, fire orders, adjustment and control of fire. Based on time of flight of the high-explosive shell, Mk. IV, the following time factors are used for certain key ranges as indicated below:

Key ranges.....(yards)..	400	800	1,200	1,600
Time of flight of shell..(seconds)..	1.1	2.3	3.7	5.2
Time factors.....do.....	1	2	4	5

(*a*) When the target appears the observer quickly designates the target to the gunner by as simple designation as possible. He then quickly estimates the range to the target, and observing the target through his glasses reads the angular movement, in mils, which the target makes while he is counting the number of seconds, that is, time factor, for the key range which is nearest his estimated range to the target. This angular movement in mils is then given in his fire order as right or left deflection.

(*b*) The fire order used for point targets has been found too slow for use against moving targets. The best results have been obtained by using a fire order with the elements in the sequence as follows:

TARGET (DESIGNATION).
DEFLECTION.
RANGE.

Example.—A tank appears in the zone of fire of a gun. The observer immediately designates the target to the gunner who, if necessary, moves the trails of the gun, and points the barrel in direction of the tank. In the meantime the observer, having estimated the range to the target, is reading the angular movement during a time factor which corresponds to the estimated range to the target. He reads this movement by aligning the zero of his horizontal mil scale on the tank, then holding the

glasses as still as possible counts the proper number of seconds. This is done very quickly, and accuracy improves greatly with practice. Assume that a tank appears in the right of his sector at a range of 900 yards, and he reads the angular movement, during two seconds, to be left 12 mils. His fire order would be as follows:

TO YOUR RIGHT FRONT, THAT TANK.
LEFT 12.
900.

His adjustment order for the second round, based on his sensings for the first round, includes merely the corrections in deflection and range. Deflection changes for the second and succeeding rounds must be based not only on errors in direction as determined from sensing each previous round but must also be based on changes of direction and speed of the target. Proficiency in estimating deflection changes to compensate for changes of speed and direction comes as a result of much training. It is impracticable to adhere strictly to the 200-yard bracket since in doing so the essential element of rapidity of fire may be sacrificed. When a burst is obtained near the target a range change of 50 or 100 yards will usually give the proper correction since the height of the target increases the probability of a hit over that of a low target.

(2) *The sight setter.*—The sight setter is an addition to the gun crew used in firing on point targets. His position is on the left of the gun where he can quickly manipulate the dials of the sight. The addition of the sight setter to the crew has been found, from experimental fire, to increase the rate of fire from 20 to 25 per cent, since in relieving the gunner of this duty, the latter can give his entire time to tracing the target. The sight setter repeats each element of the fire order and adjustment orders as they are given, and applies the corrections in deflection and range to the sight. As soon as an announced change or setting has been applied to the sight by him, he calls "check" so that the gunner may know that the change has been accomplished.

(3) *The corporal gunner.*—The gunner's chief duty is to keep the crosslines of the sight laid on the target and preferably on the front end of the target, by manipulation of the elevating and traversing handwheels. Only by keeping his eye at the sight and by constant manipulation can he accomplish this. The most important factor in speeding up fire is teamwork of

the sight setter and the gunner. When the gunner hears a change of deflection or elevation announced by the observer he may anticipate the corresponding movement of the crosslines in the sight, when the correction is applied thereto, by making a slight change in laying, to right or left or higher or lower, by manipulation of the traversing or elevating handwheel.

Example.—If, while tracing a target moving from left to right during the firing of a problem, he hears the command ***Right 5*** he knows that when the correction is applied to the sight the vertical crossline will move slightly to the left. He compensates for this movement of the crossline by laying immediately a short distance ahead of the target. When the correction has been applied the crossline will again be on or near his aiming point on the target. At any time that he is laid on the aiming point and the gun is loaded, he calls, "Fire," not waiting for a command of execution from the observer. It has been found practicable to have the gunner open the breech after a round is fired, since he is able to do this with less interference with his duty of keeping constantly laid on the target than if the breech is opened by the assistant gunner.

(4) *The assistant gunner.*—The assistant gunner's chief duties are to load and to fire the gun on command of the gunner. As soon as the breech is opened by the gunner, the assistant gunner should immediately reload and be prepared to fire the instant he gets the gunner's command to fire.

(5) *Preparatory training.*—(*a*) Preparatory training can be accomplished by "dry" shooting on an automobile, driven first across the front at a right angle to the direction of fire, at ranges from 400 to 800 yards, and at speeds from 10 to 20 miles per hour. The observer is required to estimate the range and deflection lead and to give a fire order. The instructor then calls out errors in direction and range for each shot and requires the observer to give adjustment orders, these corrections are applied to the sight by the sight setter and the gunner continuing to trace the target calls, "Fire." Fire is simulated by the assistant gunner calling, "On the way." The gunner then opens the breech and the assistant gunner loads a dummy round or simulates loading. Assume that the initial fire order given was—

THAT CAR.
RIGHT 8.
500.

and that the first round was fired with these data applied to the gun, the instructor then announces to the observer the assumed sensings of the burst, for example, *3 left, over.* The observer then gives his adjustment order based on the announced sensings. "Dry" shooting is especially essential to the training of the gunner. It requires a considerable amount of practice for him to be able to keep the gun laid on the target. It is also essential to the development of smooth teamwork between the sight setter and the gunner.

(*b*) Later the automobile should be driven at different angles to the line of fire with varying speeds and with changes of direction that will require deflection leads from left to right, and vice versa. When the angular movement of the target changes from right to left or from left to right of the line of

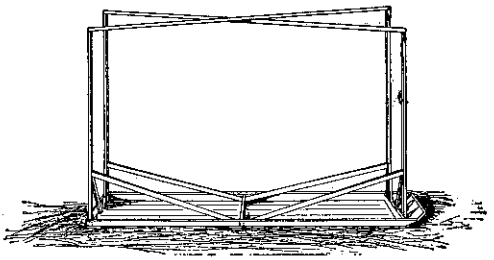


FIGURE 22.—Skeleton sled target

fire the observer should command ***Zero*** and make a new estimate of the angular speed, and announce the new deflection.

(6) *Equipment for training*—(*a*) *Target.*—A sled of the type shown in Figure 22 has proved to be the most satisfactory kind of target. It has the advantage of a low center of gravity which prevents upsetting on rough ground and in making changes of direction. The sled shown in the figure is 5½ by 3½ by 4½ feet high and weighs only 45 pounds. Figure 23 shows a similar sled covered with target cloth. In firing on this type of target it must be borne in mind that there will be no target bursts when hits are made, but adjustment must be made from bursts beyond and short of the target.

(*b*) *Towing.*—For towing the target a ½-inch rope has been found satisfactory, the power being furnished by a 1½-ton truck. The pulley shown in Figure 23 is simply a channel wheel bolted to a short length of 2-inch board. This board is staked

to the ground at a point where a change of direction of the target is desired. The knot shown in the figure should be 10 or 12 feet from the sled, depending on the speed at which the target is to be run. At faster speeds the knot must be at a greater distance from the sled to prevent the increased momentum of the sled from overrunning the pulley.

(*c*) *Set-up.*—With 500 yards of rope a set-up as shown in Figure 24 can be made. This set-up is only one of many that it is possible to make with 500 yards of rope. The one safety factor necessary is to keep the truck not less than 200 yards from the line of fire. Accidents incident to wrong laying may be prevented by keeping, just in rear of the gun, a safety officer, whose duty is to see that the barrel is kept pointed in a direction not too near the truck. The essential elements in training

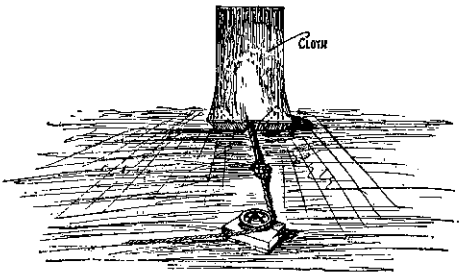


FIGURE 23.—Sled target covered with target cloth; pulley and trip knot for effecting changes of direction

a 37-mm gun squad to fire at moving targets are much practice for the observer in estimating angular speeds and for the gunner in laying on a target in motion, and for everybody, *speed.*

b. Firing at targets in trees.—The target is the aiming point during fire for effect. The following steps are necessary:

(1) Estimate the range to the tree in which the target is located.

(2) Set the deflection dial at zero and the range dial at the estimated range to the tree.

(3) Lay the intersection of the crosslines on the base of the tree by turning the elevating and traversing handwheels.

(4) Adjust fire until the center of impact is at the base of the tree.

(5) Move the intersection of the crosslines to the target in the tree by turning the elevating and traversing handwheels, and fire for effect. The deflection and range dials are not touched after fire has been adjusted on the base of the tree.

(6) In cases where it is necessary to employ indirect laying the following steps are necessary:

(*a*) Adjust fire on the base of the tree.

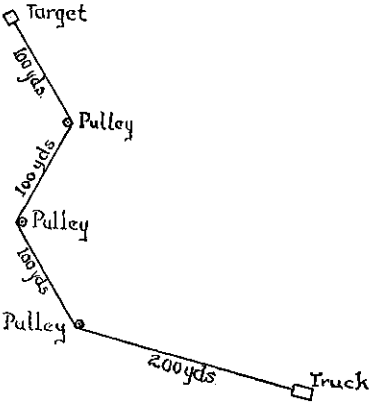


FIGURE 24.—A set-up for towing a target

(*b*) Read the vertical angle between the base of the tree and the target.

(*c*) Increase the setting of the angle-of-site dial by the value of the vertical angle read.

(*d*) Reset the range dial at the last range used in adjustment of fire.

(*e*) Fire for effect.

c. Firing at targets in buildings.—The method given in *b* above can be used in adjusting fire on targets located in buildings, particularly where the buildings are of such construction

as to allow the shells to pass through the wall before bursting, thus rendering the burst invisible to the observer. Fire is usually adjusted at the intersection of the building and the ground and the crosslines then shifted to the target by turning the elevating and traversing handwheels.

d. Night firing.—The 37-mm gun may be required to fire at night. In such cases the data for firing are determined beforehand, an aiming point which can be seen at night (called a night-firing device) is set up, and the gun is laid to hit the target. Precautions are taken to prevent enemy observation of the flash, and only fire for effect is delivered at the proper time during the night.

(1) *Determination of the firing data.*—Because of the small danger radius of the shell the 37-mm gun is not suitable for firing against areas. Hence the firing data must be exact. Such data are best obtained by actual firing during daylight. It is not desirable to adjust fire directly on the target, since it may be a machine-gun position or other similar target occupied only at night. Direct adjustment of fire would give the enemy advance information of our intention. Therefore, it is preferable to adjust fire on a point about 50 mils, or more, to the right or left of the target, and at the same range. Fire is adjusted by single rounds fired at long intervals so that the enemy's attention will not be drawn to the gun position. Full advantage should be taken of any artillery firing, the sound of which will muffle the sound of the 37-mm gun.

(2) *Laying the gun.*—After fire has been adjusted on the selected point the gun is laid so that the projectiles will strike the target. This is done by measuring the horizontal angle between point and target, setting off the angle on the deflection dial, and relaying on the aiming point.

Example.—The deflection dial, upon the completion of fire for adjustment on the selected point, is at *right 5*. The observer finds by measurement that the target is 50 mils to the right of the point upon which he adjusted fire. The deflection dial is then set at *right 55* and the gun relaid on the aiming point which was used during fire for adjustment. The gun has thus been laid so that the projectiles will strike the target. The horizontal angle between the target and the point on which fire is adjusted can be read very accurately by means of the vertical line and deflection dial of the telescopic sight.

(3) *Use of the night-firing device.*—To check the laying during night firing, an aiming point which is visible to the gunner must be used. Such an aiming point, visible in darkness, is known as a night-firing device. After the gun has been laid so that the projectiles will strike the target, the night-firing device is set up in front of the gun in such position that it is visible in the field of vision of the telescopic sight. The gunner should glance through the bore to make certain that the device will not be struck by a projectile when the gun is fired. The crosslines are then moved to the aiming mark on the night-firing device by turning the deflection and range dials. The settings of the dials are noted and recorded. Care must be exercised that the gun is not moved when moving the crossline; the elevating and traversing handwheels must not be touched. The telescopic sight is more suitable for night firing than the quadrant sight. During firing the gunner checks the laying by aligning the crosslines on the visible aiming mark. Since it is difficult to determine, during fire for adjustment, whether the target and the point on which fire was adjusted are at exactly the same range, it is advisable to lengthen artificially the beaten zone to insure the target being struck. This can be done by depressing and elevating the barrel slightly during fire for effect; a quarter turn of the elevating wheel up and down will be sufficient. A slight amount of traversing should also be carried out; a quarter turn will be sufficient in most cases. The gunner should relay on the aiming point at every fourth or fifth round.

(4) *Concealment of the gun position during firing* (fig. 25).—To prevent the exact location of the gun being determined by the enemy, the flash of the gun must be concealed as far as possible. This is accomplished by means of the flash hider and screens made of burlap sacks or canvas. The flash can thus be hidden from all places which are not directly in front of the gun, and will make it extremely difficult to determine its exact location. While the flash hider does not conceal the flash, it does reduce the illumination of objects at the gun position. Frequent inspection must be made during fire for effect to see that the blast of discharge has not forced the flash hider off the barrel. Screens should be placed as shown in the illustration (care being taken to allow for traversing the gun) and also in front of the gun, above the muzzle, in order to conceal the flash from any enemy that may be located

on higher ground. Screens should be dampened to prevent their ignition by sparks. The night-firing device must also be hidden from enemy observation.

(5) *Removal of the gun.*—It may be desirable to remove the gun between fire for adjustment and the time that fire is to be delivered at night. In such case, in order that the fire for effect may be accurate, the gun must be replaced in the exact position from which fire was adjusted. This can be effected by

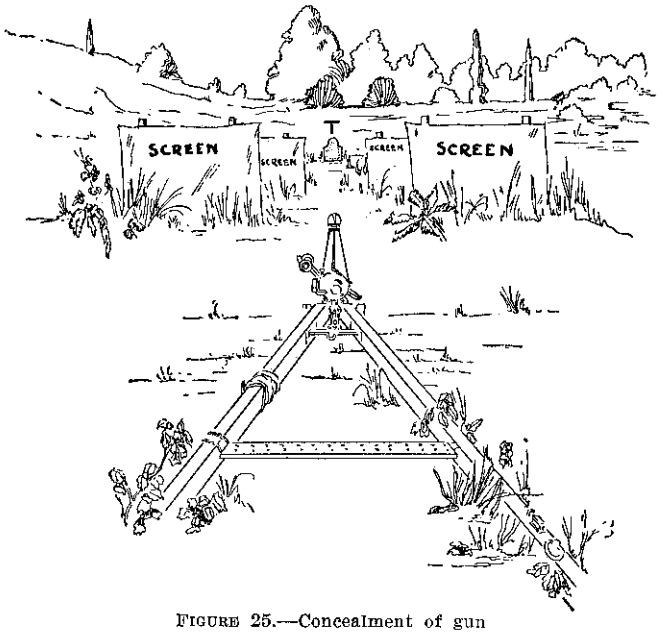


FIGURE 25.—Concealment of gun

driving short stakes at each trail spade and at the front leg float (or wheels) before the gun is removed. The gun is returned to the exact position marked by these stakes, the deflection and range dials set at the recorded settings, and the crosslines laid on the aiming point by turning the elevating and traversing handwheels. The night-firing device is left in position when the gun is temporarily removed.

(6) *Construction of a night-firing device.*—Night-firing devices can be improvised in several ways. In the end of a tin can or

box cut a cross-shaped slit and cover it with a thin white cloth to keep the glare out of the gunner's eyes. Or, remove the lid of a can, mark a heavy black cross on a sheet of paper, and fasten the paper over the open end. Punch several holes in the other end of the can. In one side of the can cut a rough cross-shaped slit and bend its edges inward to admit and hold a candle. Punch several nail holes above and on each side of where the flame of the candle will be. A candle is lighted and inserted, and the night-firing device set up in front of the gun. The crosslines of the sight are aligned on the cross of the can. A flashlight may be used for illumination if one is available.

e. Firing without sights.—(1) The 37-mm gun is not rendered useless because of loss or destruction of the sights. A quarter turn of the elevating handwheel will move the point of burst about 200 yards at ordinary combat ranges, and a quarter turn of the traversing handwheel will make a change of about 10 mils in direction on the M1916 gun. The following is an example of the approximate elevations above the line of site for the M1916 gun firing the high-explosive shell (M. V. 1276 f/s) expressed in terms of the elevating handwheel:

	Yards
One-half turn	750
One turn	1,200
One and one-half turns	1,600

(2) The trail spades must be driven firmly into the ground before the gun is laid; otherwise the sinking of the trail spades during the first few rounds will affect the elevation of the gun.

(3) To lay the gun for the first round, the gunner opens the breech and, by means of the elevating and traversing handwheels, moves the gun until the target can be seen when glancing along the bottom of the bore. He then elevates the gun by turning the elevating handwheel the number of turns (or fraction thereof), which will give the gun an elevation corresponding approximately to the range to the target. Holding both handwheels firmly, he orders a round fired.

(4) To adjust the fire, the gunner observes the burst, turns the handwheels an amount which he believes will make the necessary correction, holds the wheels firmly, and orders another round fired. He continues to do this until the center of impact is on the target. Fire for effect is then delivered. The gun commander, with his field glass, observes the effect of the fire and assists the gunner in any way possible.

f. Long-range firing.—When occasion demands firing on a target at a greater range than the highest graduation on the sight the procedure given below is followed:

(1) Target visible to the gunner; telescopic sight used:

(*a*) Estimate the range to the target.

(*b*) Refer to the range table and determine the angle of elevation which corresponds to the estimated range.

(*c*) Subtract 73 mils (the angle of elevation for 1,600 yards) from the angle of elevation for the estimated range.

(*d*) Refer to the range table and determine the range equal to the difference found.

(*e*) Set the range dial at 1,600.

(*f*) Lay the intersection of the crosslines on the target by means of the elevating and traversing handwheels.

(*g*) Set a stake in front of the gun within the field of vision of the sight.

(*h*) Set the range dial at zero. This raises the horizontal crossline, and thus raises the line of sighting 73 mils above the line of site. The axis of the bore is also 73 mils above the line of site.

(*i*) Mark the stake where the line of sighting intersects it. This is the new aiming point.

(*j*) Set the range dial at the range determined in (*d*) above.

(*k*) Lay the intersection of the crosslines on the mark made on the stake by manipulating the elevating and traversing handwheels. Adjust fire in the usual manner.

(2) Target not visible to the gunner; quadrant sight used:

(*a*) Estimate the range to the target.

(*b*) Measure the angle of site.

(*c*) Refer to the range table and determine the angle of elevation which corresponds to the estimated range to the target.

(*d*) Subtract 73 mils from the angle of elevation.

(*e*) Refer to the range table and determine the range equal to the difference found by the foregoing deduction.

(*f*) Lay the gun for direction.

(*g*) Set the range dial at 1,600.

(*h*) Center the bubble by turning the elevating handwheel.

(*i*) Set a stake in front of the gun in the same manner as when direct laying is employed.

(*j*) Set the range dial at zero.

105501°—32——9

(*k*) Mark the stake where the line of sighting intersects it. Use the horizontal line of the collimator to determine this point.

(*l*) Set the angle of site of the target on the angle-of-site dial.

(*m*) Set on the range dial the range determined by calculation.

(*n*) Place the intersection of the vertical and horizontal crosslines of the collimator on the mark made on the aiming stake, by turning the elevating and traversing handwheels. Disregard the spirit level of the sight. When the quadrant sight is used in laying the gun for long-range firing the extreme-range setting of the sight may be used, since the crosslines of the collimator are not limited in the same manner as the crosslines of the telescopic sight. However, for the sake of uniformity, and to thoroughly fix a definite range setting (with its corresponding angle of elevation) in the minds of gun commanders, it is preferable to use 1,600 for both sights.

82. Range cards.—A range card is a device for indicating ranges to various points in a field of fire. It is useful as a guide to a gun commander. Range cards are used in attack and defense and are particularly useful in highly organized defensive positions. All gun commanders are required to understand the preparation and use of range cards. Range cards form a part of the orders of a gun position and are invaluable to a gun crew making a relief. Attack range cards greatly simplify the determination of ranges to various points at which targets may suddenly appear. Duplicates of the original range cards prepared during consolidation of a newly taken position should be sent to the platoon commander. With the addition of a few explanatory notes they form a valuable source of information as to the location and field of fire of the gun. Such early reports enable the platoon commander to inform the battalion commander exactly what the gun can do in the event of hostile action and indicate where coordination and rearrangement are necessary.

a. Preparation of range cards.—(1) Range cards should be prepared on strong paper or cardboard. Waterproof ink or ordinary soft lead pencil should be used. Ordinary ink and indelible pencil will blur when wet and should not be used. All lines should be made heavy and clear, and all letters should be printed, since the card must often be read in a very dim light. One copy of each range card should be sent to the platoon commander, and one copy retained in the per-

sonal possession of the gun commander. The card at the gun position should be secured to a stake or board and placed in position where it can be easily read by the gun commander. It should be protected by a waterproof covering which will allow ready reference to the card.

(2) No fixed form of range card is prescribed, but the following description of the various steps in preparing a defense range card will facilitate instruction in this subject. To prepare a complete defense range card proceed as follows:

(*a*) Select a piece of strong paper or cardboard. Represent on this, by a point, the position of the emplacement. (Fig. 26 ①.)

(*b*) Draw a line through this point, parallel to the bottom of the paper. This is known as the base line. Using the point (gun position) as a center, draw semicircles to represent ranges of 500, 1,000, and 1,500 yards. (Fig. 26 ②.)

(*c*) Turn the paper until the base line is parallel to the front of the gun position and, without again moving the paper, draw a line in the direction of the most prominent centrally located object in the field of fire. This object need not be within the range of the gun nor need it be a target or probable target. This line is known as the "zero line" and is drawn heavier than other lines. Determine the range to this object and mark it on the card in its proper relative position. (Fig. 26 ③.)

(*d*) Without moving the paper, draw lines to other points which are targets or at which targets are likely to appear. Mark these places in their proper relative positions on the card. All prominent features on the ground which will facilitate determination of ranges to targets which may appear near these points should be shown. (Fig. 26 ④.) Mark the nature of the targets, such as "machine gun," "sniper's post," etc.

(*e*) Determine as accurately as possible (by map, range finder, or firing) the ranges to all points shown on the card. Determine the angle of site of each point. Read the magnetic azimuth of each point. Mark the data on the range card. (Fig. 26 ⑤.) Mark the direction of magnetic north, the number of the emplacement for which the card is prepared, and the date on which it was made. Number all points from right to left. The numbering of these points permits the platoon commander to order fire on "Point number —" without further description. (Fig. 26 ⑤.) Each range card should be accom-

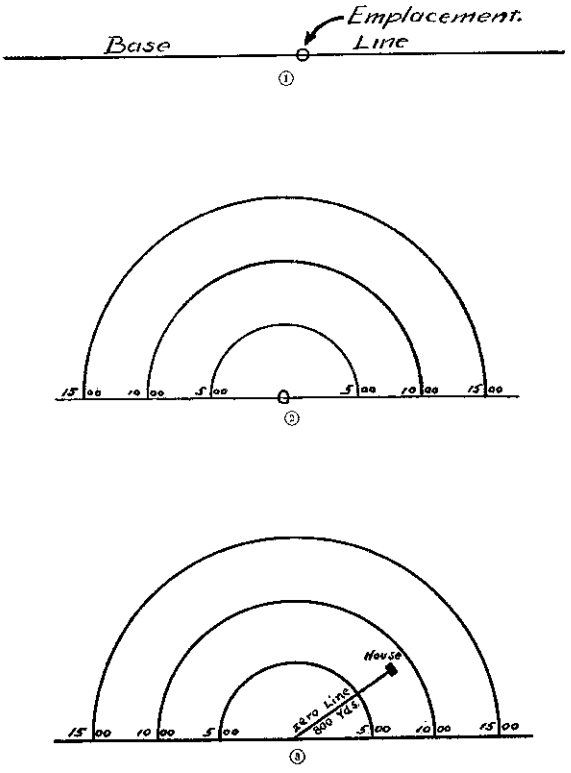
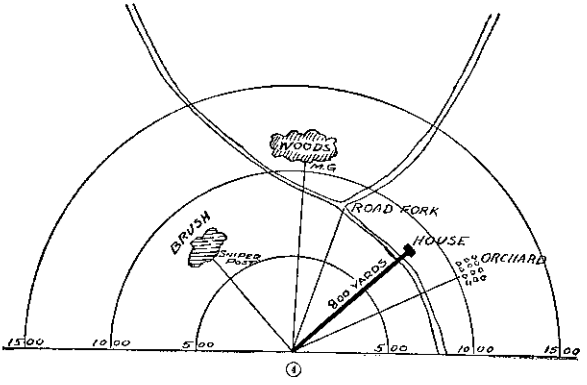


FIGURE 26.—Preparation of range cards



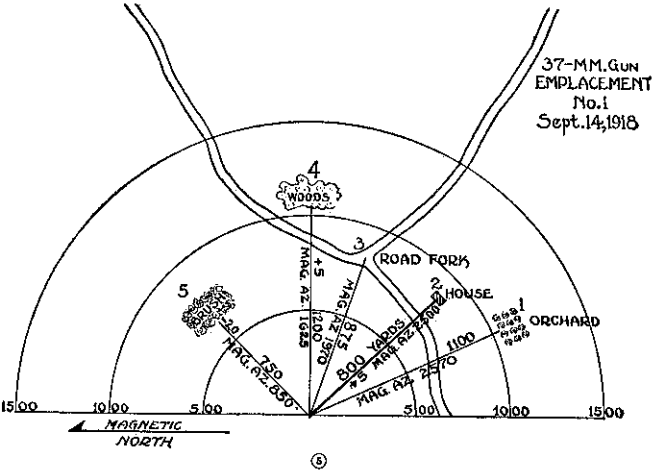


FIGURE 26.—Preparation of range cards—Continued

panied by a data sheet on which are recorded the location and nature of targets, the time and nature of their activities, and any other data which will assist a relieving gun crew.

b. Attack range cards.—(1) Figure 27 shows a simple range card for use in attack. The ranges are taken from the point of departure or first firing position.

(2) The attack range card enables the gun commander to determine quickly the range to the enemy position at any time during the advance by interpolation between the measured ranges from the key points.

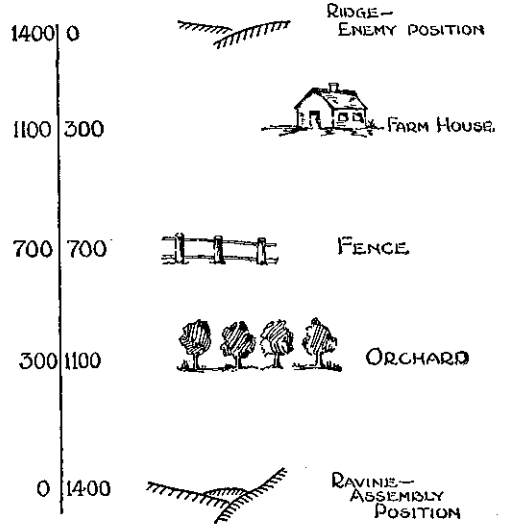


FIGURE 27.—Attack range card

c. Defense range cards.—A simple range card of the defense type should be immediately prepared upon the occupation of a defensive position. It should show the position of the emplacement, the direction of magnetic north, the field of fire, prominent features of the terrain, and the ranges thereto. Such a card is illustrated in Figure 28. This card is replaced as soon as possible with a more complete card of the type shown in Figure 26 ⑤. Whenever possible, defense range cards should be supplemented by panoramic sketches. They should always be accompanied by a data sheet. Maps which are known to be accurate should be used freely in preparing cards.

d. Message cards.—A rough sketch should always accompany any message concerning the location or emplacement of a 37-mm gun. (Fig. 29.) This sketch should show the position and field of fire of the weapon together with a north line and the ranges to any actual or prospective targets. It may be in the form of an overlay from a map, or just a rough outline sketch.

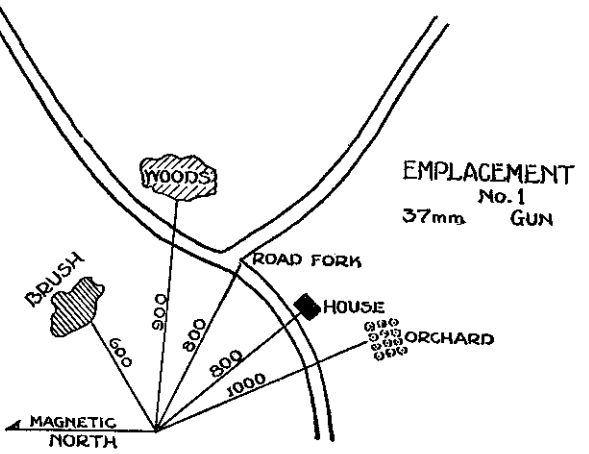


FIGURE 28.—Defense range card

SECTION II

3-INCH TRENCH MORTAR

83. General.—The principles involved in the technique of 3-inch trench mortar fire are, in general, the same as those for the 37-mm gun, although the characteristics of the weapons are opposite in many respects. This section serves as a guide to the handling of the mortar fire. It discusses in detail only the points peculiar to the 3-inch trench mortar. For a discussion of any principle common to both the 37-mm gun and the mortar see Section I.

84. Laying the mortar for direction.—The mortar is laid for direction, for the first round, by aligning the aiming line of the mortar upon an aiming point on the line mortar-target;

for subsequent rounds it is laid by traversing the barrel to the right or left of the position in which it was laid for the round just fired. In the selection of the method to be used the governing factor is that the mortar should open fire in a minimum of time and have the first round burst near enough to the

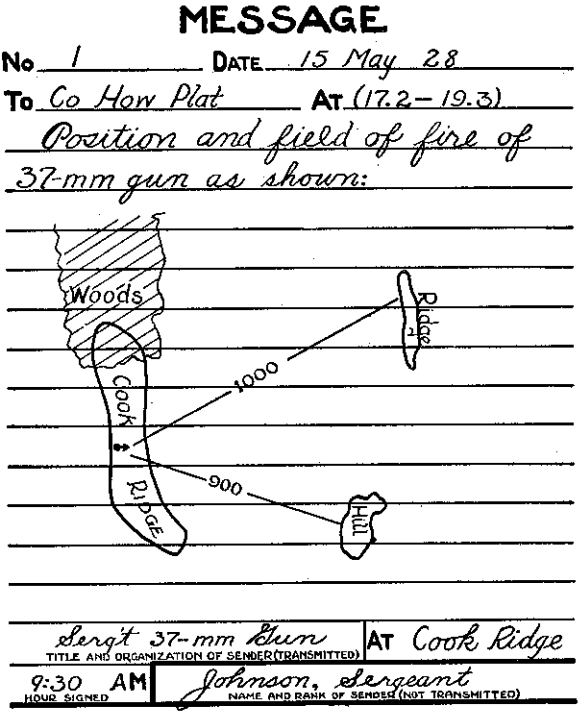


FIGURE 29.—Message

target to render the adjustment of fire possible without a movement of the weapon.

85. Establishing direction—*a. When the target is visible to the gunner.*—When the target is visible from the mortar position the mortar can be laid for direction by aligning the aiming line directly on the target. The advantage of this method is that it permits fire to be opened in the shortest possible time. The disadvantage is that it places the mortar under direct

observation of the enemy and affords no protection to the mortar and its personnel.

b. By methods common with the 37-mm gun.—The mortar can be laid for direction by use of an aiming point on the line mortar-target. When there is no suitable aiming point on the line mortar-target, the observer, if he can see the target and

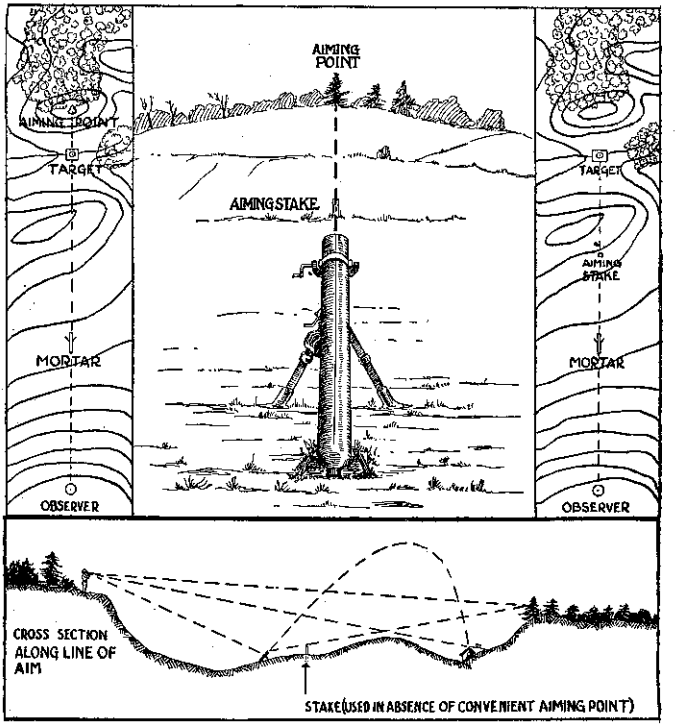


FIGURE 30.—Direction, 3-inch trench mortar

mortar from a position in rear of the mortar, may direct the placing of a stake on the line to serve as an aiming point, aligning the stake from his observation post by means of hand signals.

The aiming point having been selected the mortar is then laid for direction as described in paragraph 84. This method offers

the advantage of extreme simplicity and of requiring no member of the squad to expose himself to the view of the enemy while obtaining the direction. The methods of obtaining the direction for the 37-mm gun by use of stakes, parallel-line method, compass and mil formula, back azimuth, alidade and map and compass method, as described in Section I, are used for obtaining the direction for the 3-inch trench mortar. Any one of these methods having been used, the mortar is then laid as just described. The parallel-line method is the simplest and quickest method of obtaining the magnetic azimuth from an observation post on the flank. It is therefore preferred when a point can be found the same distance to the right or left of the line mortar-target as the observer.

86. Laying the mortar in elevation—*a. Clinometer.*—The 3-inch trench mortar clinometer is designed for laying the mortar at any required elevation. It measures the angle above the horizontal that the barrel must be elevated to strike a target at a given range. To use the clinometer in laying the mortar, proceed as described in Chapter 2, Part Two, Basic Field Manual, Volume III.

b. Fire-control tables.—The fire-control tables are divided into a range table and a deflection table. The elevation required for any given range is shown on the range table. The number of turns of the traversing handle required to correct errors in deflection are shown on the deflection table.

(1) *Description of the range table.*—The range table is divided into five columns. In the first column and on the left of the table are the various ranges at which the mortar may be fired from 250 to 750 yards, inclusive. In the second column from the left are shown the elevations at which the barrel must be laid to obtain the range shown on the same line in column 1, when a cartridge alone is used as a propelling charge. In the third column are shown the elevations for a propelling charge of a cartridge and one powder ring. In the fourth column are the elevations for a charge of a cartridge and two powder rings. In the fifth column are those for a cartridge and three powder rings. The elevations for the various propelling charges are overlapping; that is, the mortar can be laid to fire at a range of 300 yards by using a propelling charge of a cartridge alone and setting the barrel at the elevation shown in column 2, or by using a cartridge and one powder ring and setting the barrel at the elevation shown in column 3. When the eleva-

tions are overlapping, the lowest elevation is always used (unless it involves moving the legs of the mount during firing), because the fire of the mortar is more accurate at the lower elevations.

(2) *To use the range table.*—Knowing the range to the target, find this range in the first column; read in the next column to the right in which figures appear on the same line as the range, the proper elevation at which to lay the mortar; then at the top of the column in which this elevation is found, find the proper propelling charge.

Range table

Range	Cartridge alone	Cartridge and 1 ring	Cartridge and 2 rings	Cartridge and 3 rings
	Degrees	*Degrees*	*Degrees*	*Degrees*
250	58	74.5	----------	----------
275	52	73	----------	----------
300	40	70.5	----------	----------
325	----------	68	74	----------
350	----------	65.5	72.5	75
375	----------	63	71	74
400	----------	60	69	73
425	----------	56	67	71.5
450	----------	52	65	70
475	----------	45	63	69
500	----------	----------	61	67
525	----------	----------	59	66
550	----------	----------	56	64
575	----------	----------	54	62
600	----------	----------	50	60.5
625	----------	----------	45	58
650	----------	----------	----------	56
675	----------	----------	----------	54
700	----------	----------	----------	51
725	----------	----------	----------	46
750	----------	----------	----------	40

NOTE.—The above table is for use with the clinometer, Mk. I, which is graduated in degrees. The Mk. II clinometer is graduated in mils and a corresponding table showing elevation in mils must be used.

(3) *Description of the deflection table.*—The deflection table is divided into four parts according to the propelling charges used. Opposite each propelling charge is shown the number of yards that one turn of the traversing handle will change the point of impact when that propelling charge is used. The unit of measurement of deflection is one turn of the traversing handle. One turn will move the point of impact at any possible range with the cartridge alone as a propelling charge, 4

yards; with the cartridge and 1 powder ring, 6 yards; with the cartridge and 2 powder rings, 8 yards; with the cartridge and 3 powder rings, 10 yards. That is, the change in deflection made by one turn of the traversing handle for any given charge is the same at all ranges possible with that charge.

Example.—Suppose that the mortar is laid with the traversing mechanism centered and the barrel at an angle of 45° and a round fired with any given charge. Then the barrel is elevated 5° and another round fired with the same charge. This elevating of the barrel and firing are repeated until (provided the elevating screw were long enough) the barrel is pointing straight up. Theoretically the round fired from this position would fall on the mortar. The points of impact of the other rounds fired would have approached the mortar in a straight line. Suppose now the mortar is returned to the position from which the first round was fired and the barrel traversed three turns to the right. A round is fired with the same propellant that was used for the previous firing and the former procedure of elevating the barrel 5° and firing a round at each elevation repeated until (provided the elevating screw were long enough) the vertical is reached. It will be found that the barrel is not in the true vertical, but that it is inclined to the right the same amount which it was traversed when it was at 45°. A round fired with the barrel in this highest position would fall as far to the right of the mortar as a round fired from the 45° position would be to the right of the point of impact of the round fired from the 45° position with the traversing screw centered. The points of impact of the rounds fired when the barrel was traversed three turns to the right would lie in a straight line parallel to the line of the points of impact established when the traversing screw was centered.

(4) *To use the deflection table.*—It is necessary to know the range at which the next round is to be fired and the propellant for that range. Knowing the propellant which is to be used, the number of turns of the traversing handle necessary to correct the deflection error of the preceding round can be determined.

(*a*) Find opposite the propelling charge to be used the number of yards that one turn of the traversing handle will change the deflection. Divide the desired correction by this figure and the result will be the number of turns of the traversing handle that must be applied to the mortar to correct this deflection.

Example.—Suppose a round to have been fired at a target with an estimated range of 475 yards and that an elevation of 45° and a cartridge and one ring were used. The round was observed to have been a "short" and 40 yards to the right. By reference to the range table it will be found that a propelling charge of a cartridge and two rings will be used for the next round. By reference to the deflection table it will be found that when a cartridge and two rings are used a deflection of 8 yards is obtained. Divide the total amount of change desired (40) by the amount of change that one turn of the traversing handle gives (8) and the result will be the number of turns (5) of the traversing handle necessary to correct the desired deflection.

(*b*) The figures shown in the deflection table are mathematically and theoretically correct. However, due to the various factors and conditions which affect the accuracy of the fire of the mortar, such as the errors in the estimation of the range and deflection, the shifting of the base plate, the effect of the wind during a comparatively long time of flight, and variations in the bomb and propelling charge, exact methods of adjusting for errors in direction are not practical. A method which speeds up the fire by simplifying the observer's calculations is to assume that, for all ranges and propellants, one turn of the traversing handle will move the strike of the shell 8 yards in direction. The apparent inaccuracy of this method is more than compensated for by its simplicity.

Deflection table

Propelling charge used	Number of yards that 1 turn of the traversing handle will move point of impact
Cartridge alone	4
Cartridge and 1 ring	6
Cartridge and 2 rings	8
Cartridge and 3 rings	10

(5) *To lay the mortar in elevation.*—To lay the mortar at the proper elevation it is necessary to know only the range to the

target. Knowing this, from the range table, obtain the proper elevation to lay the barrel to reach this range. By means of the clinometer and elevating mechanism lay the barrel at this elevation. The mortar has then been laid in elevation.

87. Fire control and adjustment—*a. General.*—(1) Fire for adjustment is that class of fire used to bring the center of impact on the target. Because of the high angle of the trajectory of the 3-inch trench mortar shell and the resulting vertical fall, it is not necessary to consider the angle of site. When the target is on ground higher or lower than the mortar position, fire is opened and adjusted as though the mortar and the target were on the same level.

(2) When mortars are grouped to fire at the same target, fire is adjusted by one mortar, which is designated by the group commander. When this mortar has adjusted, the data thus obtained are applied to the others in the group.

(3) At 700 yards the zone of dispersion is about 60 yards long by about 40 yards wide; the length of the 50 per cent zone being about 30 yards. On account of the large radius of action of the shell, a strike within 10 yards of the target is considered a direct hit. This comparatively large zone of dispersion and effective radius of the shell make the 3-inch trench mortar particularly adaptable to the searching of areas and for fire at targets which can not be located exactly.

(4) If in adjusting fire a wild shot occurs in a series of rounds which have been responding to corrections in a satisfactory manner, the round may be disregarded or given only a partial correction, as the round was probably one of the small per cent which fall in the outer part of the shot group. The mortar will not be fired when friendly troops are within 200 yards of the point where the shell would be expected to strike.

b. Control of fire.—The principles governing the control of the fire of the 37-mm gun apply to the fire of the mortar. The original fire order contains the following data in the sequence shown: Type of shell to be used; range; aiming point; number of rounds. In giving the fire order unnecessary words are omitted. A typical fire order would be:

HIGH EXPLOSIVE.
650.
STAKE.
ONE ROUND.

The command — ***rounds*** indicates that the mortar is to be laid at once and to be fired when so laid. Subsequent fire orders correct for deflection and in addition contain such data of the original order as are changed and the number of rounds to be fired. An example is:

LEFT ONE TURN.
ONE ROUND.

c. Adjusting fire—(1) *General.*—The position of the observer with respect to the line mortar-target has the same effect on the observation of errors in range and deflection as in the case of the 37-mm gun. Errors in deflection are estimated in yards rather than measured in mils.

(2) *Adjustment for range.*—The bracketing method for adjusting the fire of the 37-mm gun for range applies also to the 3-inch trench mortar, except that, due to the limited range of the mortar, a bracket of only 100 yards is used.

(3) *Adjustment for deflection.*—Errors in deflection are corrected by estimating the amount of error and applying the deflection table as previously described.

88. Arm-and-hand signals—*a. To change deflection.*—Thrust the hand out horizontally to the full extent of the arm, in the direction in which the change in deflection is to be made, beginning the thrust at the shoulder with the palm of the hand down. Each thrust with the fist closed signifies one-half turn of the traversing handle; with the hand open, one complete turn of the traversing handle.

b. To increase the range.—Thrust the fist upward vertically from the shoulder to the full extent of the arm once for each increase of 25 yards; thrust it downward vertically in the same manner for each decrease of 25 yards.

c. To fire (so many) rounds.—Extend the arm toward the gunner for whom the signal is intended, with hand raised and the palm toward him; expose the fingers to indicate the number of rounds to be fired, 1 finger for 1 round, 2 fingers for 2 rounds, and so on.

89. Fire for effect.—Fire for effect is that class of fire used to destroy, immobilize, or neutralize a target. It is divided into four classes: Fixed fire, traversing fire, searching fire, and oblique traversing fire. The number of rounds to be fired to effect the destruction of a target must be decided by the gun commander. If more than five rounds are ordered, the firing is done in series of five rounds, the mortar being relaid after each

series. The command ***Fire for effect*** is not used. To order fire for effect the gun commander commands: — ***ROUNDS.***

a. Fixed fire.—Fixed fire is that class of fire in which the mortar is directed and fire delivered at a single fixed point. After fire has once been adjusted no change in elevation or deflection is made except to keep the center of impact on the target. The fire is designated either to consist of a certain number of rounds to be fired at a certain rate, or to be continued at a designated rate until the mission is accomplished.

b. Traversing fire.—Traversing fire is that class of fire which is distributed laterally. It is accomplished by traversing the mortar one or more turns of the traversing handle to the right or left after each shot or series of shots. One turn of the traversing handle to the right or left after each shot is the method usually employed. This operation is continued until the right or left limit of the area to be shelled is reached, when the operation is reversed. This procedure is continued until the mission is accomplished.

c. Searching fire.—Searching fire is that class of fire which is distributed in the direction of depth. It is accomplished by a short increase or decrease of elevation after each shot. The usual method is as follows: Open fire on one of the extreme limits, in depth, of the area to be shelled. Decrease or increase the range 25 yards after each shot until the opposite side of the area has been reached, when the operation is reversed. This operation is continued until the mission has been accomplished.

d. Oblique traversing fire.—Oblique traversing fire is that class of fire which is a combination of traversing and searching fire, and is accomplished by a combination of the two methods. After each shot the mortar is traversed to the right or left as described in *b* above, and the range increased or decreased as described in *c* above.

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